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UNIVERSITY OF ARKANSAS

COLLEGE OF AGRICULTURE

# Agricultural Experiment Station

## ARKANSAS COTTON DISEASES

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FAYETTEVILLE, ARKANSAS

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## ARKANSAS COTTON DISEASES

JOHN A. ELLIOTT.

All of the important cotton diseases found in the cotton growing states occur in more or less severe form in Arkansas. On account of differences in climatic conditions, however, Arkansas does not suffer as severe losses from cotton diseases as do some of the other southern states. Losses vary also from season to season because of the variations in temperature and rainfall, and a disease which may cause the heaviest losses one year may, on account of differences in weather conditions, be of little importance another year. The type of soil, length of season, and soil fertility are all factors that enter into the problem of cotton diseases, so that even in a single season a disease causing damage in one part of the state may be unimportant in another. The length of time a field has been under cultivation, especially where little attention has been given to crop rotation, may greatly affect the severity of some of the worst cotton diseases.

The toll of cotton diseases in Arkansas during the time that fairly reliable records have been kept has been from ten to thirty per cent of the crop. This estimate is not meant to include the rotting in the field that may occur due to late picking, although this rotting also is caused by fungi. The money loss will of course vary with the price of cotton and be greatest when the price is highest. In 1919 the total loss to the state from cotton diseases was not less than fifteen million dollars.

In spite of the general prevalence and importance of the various cotton diseases, many growers know little about their nature, and seldom distinguish between them. Ordinarily all diseases are designated as "blight", "rust", and "boll-rot", while sometimes all of them are called simply "blight." It is the purpose of this bulletin to distinguish between various cotton diseases, tell their causes, and as far as is known, give the most recent methods of control.

### WILT

Cotton wilt is the most serious of all the cotton diseases, because the wilt organisms may live for many years in the soil. It causes heaviest losses on the lighter soils with poor water holding capacity. It is a common and widespread disease in Arkansas, particularly in the eastern part of the state. In western Arkansas it is much less common, although few fields are entirely free from the disease. Infected land that is planted year after year to cotton may become so heavily diseased that cotton will fail entirely. (See Plate I, Figs. 1, 3, and 4.)

The disease has the characteristics of all the wilts of its class. The symptoms are, first, a bronzing, and then a yellowing and drooping of the leaves. Finally all the leaves, squares, and many of the small bolls are shed. The larger bolls may remain on the plant even when it dies, although only the more mature bolls will ripen. The plants may die entirely, or struggle along, putting out new shoots from the bases of the branches, especially the lower ones. If the weather turns decidedly moist following a season of drouth many of the diseased plants may make considerable growth. On heavy, fertile soil which is infected, the plants may make a very encouraging early growth during a wet season, only to go down rapidly if the moisture supply becomes a little short later in the season. This fact has led many of the cotton growers to refer to this disease as "blight." If any doubt remains as to the identity of the disease it can be entirely removed by cutting across the stem of the plant. If the interior shows brown or blackened spots and rings in the wood, the trouble may be definitely ascribed to wilt. If the interior is clear white or light green, the trouble is due to some other cause. (See Plate I, Fig. 2.)

**The Cause of Wilt.** Cotton wilt is due to a fungus, *Neocosmospora vasinfecta* (Atk.) E. F. Smith, which lives in the soil and infects the plant through the roots. It invades the water carrying vessels of the plant and thereby cuts off the water supply from the leaves and other parts of the plant. The rapidity with which the plant dies depends on the severity of the infection and also on the available water supply. With plenty of water in the soil an infected plant might live which would quickly succumb if the soil became a little drier. It is on this account that the disease is more severe on soils with poor water holding capacity. The well observed fact that wilt is more severe in a wet season than a drier one is because the weather conditions which favor a rapid "sappy" growth of the cotton plants also favor the development of the wilt fungus, and if the water supply becomes at all short, such plants suffer quickly and severely.

**Control.** Every effort should be made to prevent the introduction of the disease on healthy soil and to prevent its spread. Any means by which soil from diseased fields may be carried to healthy land should be guarded against. Seed from diseased plants may carry the disease but this has not been definitely proved. It would be hard to account for some infections unless the wilt can be carried in this manner. Where the disease has been introduced it may be partially reduced by crop rotation, especially when root-knot is also present in the soil (7). Finally, if the disease becomes severe enough to make the growing of the

ordinary staple varieties of cotton unprofitable, wilt resistant varieties should be used. Several of these have been originated by Orton of the Bureau of Plant Industry which have given good results (6). The leading varieties are Dixie, Dix-Affii, Dixie Triumph, and Dillon. A selection of wilt resistant Express, which shows some promise, but which needs further development, was made by Mr. Ayers of the Arkansas Experiment Station. A large acreage of cotton land in Arkansas has reached such a degree of infection as makes the growing of ordinary varieties hazardous, and the introduction of the wilt resistant varieties necessary.

### ANTHRACNOSE

Anthracnose is one of the most widely known of the cotton diseases and one which has been studied for many years. It is far less important in Arkansas than it is in many of the cotton states, particularly those east of the Mississippi River. It does, however, cause heavy losses when a field becomes heavily infected. Infection occurs on leaves, stems, or bolls and may take place at any time. It is most conspicuous on the bolls after mid-summer, although the infection may have occurred much earlier. On the bolls it may be observed as circular dark-brown spots which, as they enlarge, usually have bright orange-pink centers, caused by a thick coating of the fungus spores. One or many spots may appear on a boll. The fungus penetrates the boll, rotting the lint and attacking the seed. Moist, warm weather favors the spread of the disease. Anthracnose very commonly follows other injuries, particularly angular leaf-spot lesions. (See Plate II, Figs. 1, 2, 3, and 4.)

**Cause.** Anthracnose is caused by a fungus known as *Glomerilla gossipii* (Atk.) Edg. which may live over winter on diseased stalks in the fields and infect the following crop, but which is spread much more commonly by infected seed. In diseased bolls many seeds are killed by the anthracnose fungus. Some, however, may be attacked without being killed, but carry the fungus over in the seed coat or diseased seed leaves until the following spring. When the diseased seed is planted the fungus begins to grow as the seedling germinates, and may be seen as a leaf spot on the young plant. In some cases the stem of the plantlet is attacked and the plant is killed. If the season is moist at the time the cotton is coming up, a few diseased plantlets may cause a general infection of a field, while the same seed planted at a slightly different date and starting to grow during a dry spell may produce a crop with very little infection, since the spread of the disease is greatly retarded by dry weather.

**Control.** The disease can be controlled by planting disease



free seed on clean land (3). The fungus and the spores will not live over either in or on the cotton seed, to the second season from the year it was grown. Barre of South Carolina has proved that the fungus is even shorter lived in the field than on the seed (1). Seed that is properly kept over until the second season should give an anthracnose free crop when planted on land free from disease. Much of the cotton in Arkansas is only slightly infected with anthracnose. A large part of the most severely diseased crops in Arkansas have originated from diseased seed from east of the Mississippi River. This is particularly true of "half-and-half" cotton. The disease could be eliminated in a few years in Arkansas if a general campaign of control could be enforced. As long as diseased and clean cotton is sent through the same gins the disease will be present in greater or less severity in most fields.

### ANGULAR LEAF-SPOT

The disease which is most generally distributed in the state, and which in some seasons does more damage than any other, is the Angular Leaf-Spot. This disease is often called "rust" but the term is not very descriptive. "Angular leaf-spot" describes it much better. The disease appears in the spring as soon as the plants come out of the ground and may then be seen on the seed leaves as circular spots which have the appearance of having been water-soaked. On the later leaves it is always in the form of sharp-cornered spots, bound by the leaf veinlets. (See Plate III, Figs. 1, 2, and 3.) The spots appear first on the lower side of the leaf, and then penetrate to the upper side. In the early stage they appear as dark green, water-soaked spots. If the leaf is held toward the light, the spots appear translucent. Later the diseased tissue turns dark brown. Very commonly a yellow gummy substance exudes from the diseased spots, and particles of soil often cling to this ooze on the lower surface of the leaves. The infection often follows a vein of the leaf, making a zigzag line along each side. Leaf petioles are killed, causing the leaves to die and dry up. Badly spotted leaves usually fall early. Secondary fungi invade the spots, especially late in the season, and cause further destruction of leaf tissue. Dark streaks due to the disease may appear on the stem or branches, but the phase of the disease known as "black-arm" or "dead-arm" is not common in Arkansas. On the bolls the disease appears as dark green, water-soaked, raised, circular spots which may become dark brown and sunken in the center, especially when invaded by secondary rots. Infections on the squares often run down to the base of the boll, which may become infected and killed, especially if the boll is young. Bolls are often infected at the base underneath the

**COTTON PLOT, FAYETTEVILLE, 1919**

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Plants in rows 1 to 8 were from treated seed; rows 9 to 16 untreated. Row 9, 1910 seed; row 10, 1911; row 11, 1912; row 12, 1913; row 13, 1914; row 14, 1915; row 15, 1916; row 16, 1917, when the plot was first planted in 1918. The letter "x" represents the plants from which the infection started in 1919; "v" represents the plants which became infected from the natural spread of the disease; "o" represents the disease free plants. The rows were too far apart for the plants to touch across the rows. The 1918 season was unfavorable to the spread of the Angular leaf-spot.

No disease appeared on any except the one and two year old untreated seed the first year. The plan of the plot was kept the same for the two seasons, seed from the previous season being planted in the same rows the following year. The infection never spread to the disease-free rows, and the healthy plants kept all their leaves until they were killed by frost. Angular leaf-spot spread in the rows from the plants originally showing the disease to adjacent plants. In this plot the check rows were on the lower side of a rather steep slope which was unfavorable to the spread of the disease to the rows grown from treated seed.

In the experiment at Burdette most of the seed was planted in virgin soil and gave no evidence of Angular leaf-spot or anthracnose at any time during the season. Part of the seed was planted on isolated land that had previously been in cotton; this also remained free from angular leaf-spot and anthracnose. A third field, which had raised a badly diseased crop the previous year, was planted to treated seed. This field was separated from a field of untreated seed only by a narrow drainage ditch over which was a foot-bridge on a path traversing both fields. At the time of thinning, the field from treated seed was entirely free from angular leaf-spot, while in the other field nearly every plant was severely attacked. Swarms of plant lice covered the plants in both fields. Later in the season infection began to spread along the path in the treated field and later the infection became fairly general although not severe. Scattered anthracnose infections appeared in the fields from untreated seed, but none in the treated fields.

### ROOT-KNOT

Less is known about the prevalence and losses due to root-knot of cotton in Arkansas than about most of the other cotton diseases. This is because the disease does not appear on the parts of the plant above ground and does not attract the notice of the grower. Cotton on infected soil may make a very poor growth or even die out without any apparent reason. The fact that cotton on root-knot infested land will respond to fertilizers increases the liability of the farmer to overlook the real source of trouble and to lay all the charge against the infertility of the soil. If root-crops are grown on infested soil the trouble be-

comes immediately apparent. (See Plate V, Fig. 4.) The pest affects all susceptible crops alike, causing swellings, nodules, and distortions of the roots and a stunting of the growth of the plants. As a rule the swelling is less on cotton roots than on many other plants. Many of the small roots and rootlets may be killed and rot off, but it is only in the most heavily infested ground that the cotton actually dies. Root-knot is most serious in combination with wilt since the root-knot injury opens the way for wilt infection and makes the use of wilt resistant varieties less effective in combating wilt. Root-knot, like wilt, is most severe on sandy soils of poor water holding capacity. The most severe infestations in the state are in the coastal plain and sandy hill regions of the south and south-west Arkansas, although severe cases of infection occur elsewhere and may be found anywhere in light soils.

**Cause.** The trouble is caused by a minute worm or nematode (*Heterodera radicola*) which infests the soil and bores into the roots of the plants. The roots begin to form galls or abnormal growth as a result of the injury. The worms multiply inside the plant tissues, living at the expense of the plant. The female nematodes become full of eggs and in this distended condition may be seen as spherical white dots about half the diameter of the head of a pin. The eggs are the resting stage in which the animal lives over winter.

**Control.** As soon as the eggs hatch they must have a suitable plant on which to feed, or they will die of starvation. Practically all truck crops are attacked, as are a great many weeds, many legumes, peach trees, fig trees, and other woody plants. All plants liable to be attacked must be avoided in any program of crop rotation designed to eliminate root-knot. Small grains, corn, and sorghum are not attacked. Iron cow-peas, peanuts, beggar weed, and velvet beans among the legumes are immune. A small grain crop followed by a resistant legume, or corn intercropped with iron cow-peas, will starve out the nematodes, or very greatly reduce them if the ground is kept clean of weeds on which the pest may live.

### PHOMA BLIGHT

A disease entirely new in the records of cotton diseases was called to the attention of the State Pathologist in June of 1920 when a severe outbreak of a new blight occurred in the Petit Jean river valley in Logan and Yell Counties of this state. Edgerton (2) and Faulwetter (3) each have mentioned a *Phyllosticta* on cotton bolls but it is not at all probable that this is the same disease. A general survey of the state failed to reveal

it in any other section although replies to written or verbal inquiries indicate some other possible areas of infection. The disease appeared suddenly during a spell of cold wet weather in early June, attacking all parts of the plant above ground, but especially the stems at the base of the leaves. The symptoms are, first, a dark red sunken spot at the base of the leaf, which enlarges very rapidly, extending up and down the stem about twice as fast as around it. The centers of the spots become light brown, and then are covered with black spots which in a few days become gray with the spores of the fungus. When a spot has extended entirely around the plant the parts above wilt and dry up. On the leaves, during the wet weather, the spots make very rapid growth and at first have the appearance of large water-soaked spots which later turn brown with a darker edge. In drier weather the spots are smaller and brown from the beginning. On the bolls the spots are similar to those on the stem. The spots are checked by drouth, and extend again rapidly during damp weather. After weather conditions have checked the disease many plants recover by branching out below the injured part, making low bushy plants (See Plate IV, Figs. 1, 2, and 3.)

**Cause.** This blight is a fungous disease caused by a species of *Phoma*. Artificial inoculation experiments show that infection may take place on the leaves or stem on either wounded or unwounded tissue under proper conditions of humidity. During continuous rainy weather the spots spread very rapidly on all parts of the plant. During dry weather infection can be induced only through wounds and the spots enlarge very slowly. Infections have never been produced on the bolls artificially except by first wounding the bolls, and natural infections have been found only on injured bolls.

**Control.** It will not be possible to give definite control measures until more is known of the life history of the fungus and its ability to live over from year to year on decaying vegetable matter in the soil. At least a two year rotation would seem advisable on fields that have suffered from the disease.

### SORE SHIN

This disease is more or less limited to the heavier soils in cool, wet weather when it is impossible to work the land. The disease may appear in any field under conditions favorable to it. The disease appears as a dark wound on the stem of the cotton plant at the soil line. If the wound is deep enough and girdles the stem, the plant will die. A change in weather conditions, however, that allows the surface of the soil to dry out and permits stirring the soil with a cultivator or harrow, checks the dis-

ease and most of the plants recover, leaving scars where they were attacked.

**Cause.** The disease is caused by a fungus known as *Rhizoctonia* which seems to be present everywhere in the soil but which attacks the cotton only under conditions particularly favorable to the fungus and unfavorable to the cotton plants.

**Control.** Deep plowing and good drainage and, whenever the condition of the soil permits, working the surface to aerate the soil, lessen the danger from sore-shin. Aside from these precautions the conditions favoring the disease are largely beyond the control of the farmer.

### TEXAS ROOT-ROT.

Only a few reports of Texas root-rot have come to the Experiment Station, indicating that the disease is of little importance in Arkansas. The infections reported were in Miller County on heavy river bottom soil. Plants affected by the disease wilt suddenly and dry up, especially on hot days following rain. The disease always occurs in spots, which enlarge from year to year, as it is entirely a soil disease. Roots of diseased plants are shrunken and rotted and when wet the bark of the roots slips off easily from the wood.

**Cause.** The disease is caused by a fungus *Ozonium omnivorum*, Shear which lives in the soil and attacks susceptible plants. It may often be seen as a white web-like growth on the roots attacked.

**Control.** Deep plowing to assure better drainage and a rotation of immune plants, such as wheat, corn, and sorghum has been shown to reduce greatly the injury from this disease (8.)

### MYCOSPHAERELLA LEAF SPOT

This disease may appear at any time during the summer from the unfolding of the first leaves until frost. It forms more or less numerous light brown circular spots with bright red-brown borders scattered over the leaf surface. These spots seldom become as large as a quarter of an inch in diameter and are usually much smaller. (See Plate V, Fig. 2.)

**Cause.** The disease is caused by a fungus known as *Mycosphaerella gossypina* Atk.. The fruiting bodies of the imperfect or cercospora stage are easily seen as dark specks on the light brown centers of the spots. The disease causes little damage and no control measures are necessary. It seems to be present every-

where and will appear on cotton grown from treated seed far from where cotton had been previously planted.

### ALTERNARIA LEAF-SPOT

Probably more than one species of *Alternaria* is accountable for the spots credited to this genus of fungi. The spots may appear at any time during the year, but are particularly numerous in late summer and fall. The spots are dark throughout, with no conspicuous border or center, although dim concentric rings may appear on the larger spots. (See plate V, Fig. 1.) A great deal of the leaf tissue of the older leaves may be destroyed, and as the diseased tissue tears and cracks the leaves become very ragged. The disease is sometimes known as "black rust."

**Cause.** Faulwetter (4) has proved that a fungus known as *Alternaria tenuis* Nees may be isolated from the spots and is capable of producing them. Possibly other species of the genus may also cause spotting. Most of the injury is to leaves previously attacked by the angular leaf-spot organism. The fungus seems to be present almost everywhere. No control measures are considered necessary.

### COTTON BOLL ROTS

Several rots of cotton bolls are caused by fungi which do not seem capable of attacking any other part of the plant, or at least are unimportant as diseases on other parts. Anthracnose, Angular leaf-spot, and *Phoma* blight have already been described as they appear on the bolls.

### DIPLODIA BOLL-ROT

This disease was discovered and described by Edgerton of the Louisiana Experiment Station (2). The disease is common in Arkansas and does considerable damage during some seasons. The disease usually attacks the boll from the stem end, appearing as a dark green or brown water-soaked spot. It advances very rapidly, and soon involves the whole boll. (See Plate II, Fig. 6.) By the time the boll is entirely rotted, tiny blisters begin to appear on the surface; from these, black sooty masses of spores are released and cover the whole surface of the boll. The boll is completely rotted. Infection appears to take place only on injured bolls. The cause of the disease is a fungus, *Diplodia gossypii* Edgerton, which lives over in the field on diseased plants and is also undoubtedly carried on seed. Rotation of crops and destruction of cotton stalks have been suggested as means of control.

### FUSARIUM BOLL-ROTS

At least two species of fusarium may cause boll rots of cotton. The more common one may follow any wound or other injury, especially angular leaf-spot lesions, and cause a slow decay of the boll and lint. The spores appear on the surface of the dark spots in irregular pale pink or nearly white patches. The lint is stained slightly by the attack, and in time may be entirely rotted. (See Plate II, Fig. 5.)

Another *Fusarium* which has been studied somewhat more completely by the writer, produces a brilliant pink rot of the cotton lint and has spores which are bright pink when seen in masses on the surface of the rotting bolls. On artificial media the same bright pink staining of the substratum occurs as on cotton lint. On agar the stain extends far beyond the growth of the mycelium. The rot progresses with great rapidity and soon involves the whole boll. Bolls in all stages of maturity have been inoculated artificially and are quickly destroyed. Its progress is about as rapid as that of the diplodia rot. The spots are at first a dark water-soaked green. Later they become dark brown, and then bright pink with the spores of the parasite. The parasite is not known to attack uninjured bolls. No specific name has been given to the fungus, and no mention of this disease has been found in the literature of cotton diseases.

### RHIZOPUS ROT

This rot has been observed only following boll worm injury when a large part of the lint has already been destroyed by the "worm." It is probably not of much importance.

Other fungi occasionally cause rots of cotton bolls in Arkansas under conditions especially favorable to the fungi.

### NON-PARASITIC DISEASES

A disease sometimes called "potash hunger" or "red rust" is often seen on land of low fertility. This is not due to a plant parasite but to a lack of potash in the soil. The disease is indicated by a general unthriftness of the plants and by a marked reddening of the leaves similar to autumn coloring on maple leaves. There is an abnormal amount of shedding of squares accompanying the other symptoms. The trouble is more evident in dry years than when there is a sufficient water supply throughout the season. The trouble can be remedied by supplying the necessary potash in some form of fertilizer.

**Sun Scald.** In dry, hot seasons many of the cotton bolls may be injured by excessive heat or light, which causes first a red-



dening and then an actual killing of the side of the boll exposed to the greatest intensity of the sun's rays. This is most noticeable on the south-west side of the plants, where every boll may be burned and cracked open. On bolls less severely burned abnormal growth may occur on the inside of the pod and on the seed coats in the injured bolls. This growth breaks down easily and paves the way for the entrance of boll rots. (See Plate V, Fig. 3.) Conditions under which this trouble occurs are mainly beyond the power of the grower to control.

**Lightning Injury.** Lightning injury in cotton fields is very common in Arkansas in seasons of frequent thunder storms. When the symptoms are not familiar, the injury may be puzzling to the grower. The injured spots are almost always circular in outline, with the first dead plants appearing in the center. Plants may continue to die for several weeks following the first appearance of the spots. The plants dying earliest show no peculiar symptoms, but those which die later may be seen to have an injured area at the surface of the soil above which the stem of the plant has enlarged and below which, although the root may still be alive, there has been no growth. (See Plate V, Fig. 5.) This condition is caused by the fact that the upper part of the plant is able to get water from the roots, whereas no food from the leaves can get past the injured area to supply the roots, which slowly starve to death.

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## PLATE I.

1. Wilt on delta land, Earle, Arkansas.
2. Cross and longitudinal sections of a cotton stem diseased with wilt. (Photo. by Rosen.)
3. Wilt on sady land near Pine Bluff. This field was also suffering from "potash hunger." (Photo. by Rosen.)
4. The beginning of trouble. A single wilted stalk in a healthy field.
5. A plot of disease-free cotton, Fayetteville, Arkansas. The photograph was taken October 30, 1919.

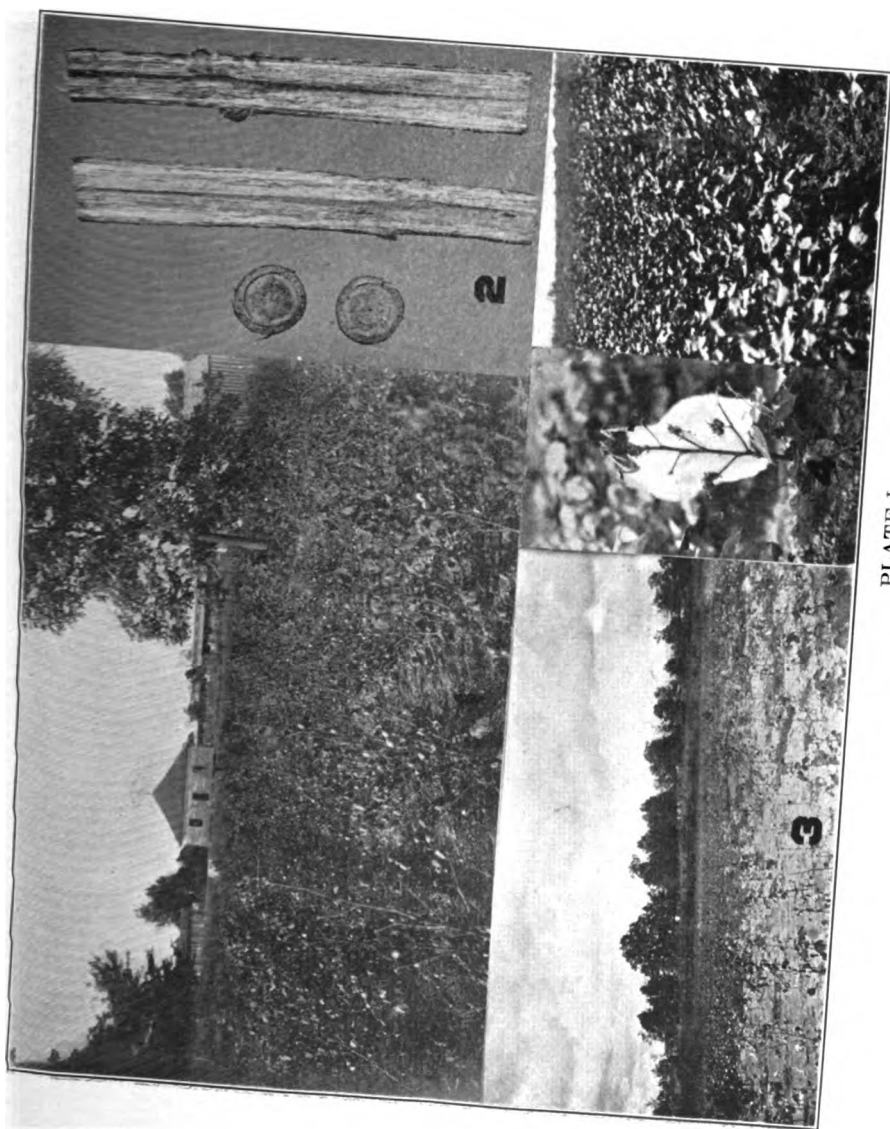


PLATE I.

## PLATE II.

1. Cotton Anthracnose on bolls, showing progress of the rot.
2. Early infection of anthracnose.
3. Anthracnose boll split open.
4. Anthracnose spot on cotton stem. (Photo. by Hewitt.)
5. Cotton bolls rotted by *Fusarium sp.*
6. Diplodia boll-rot showing pustules.

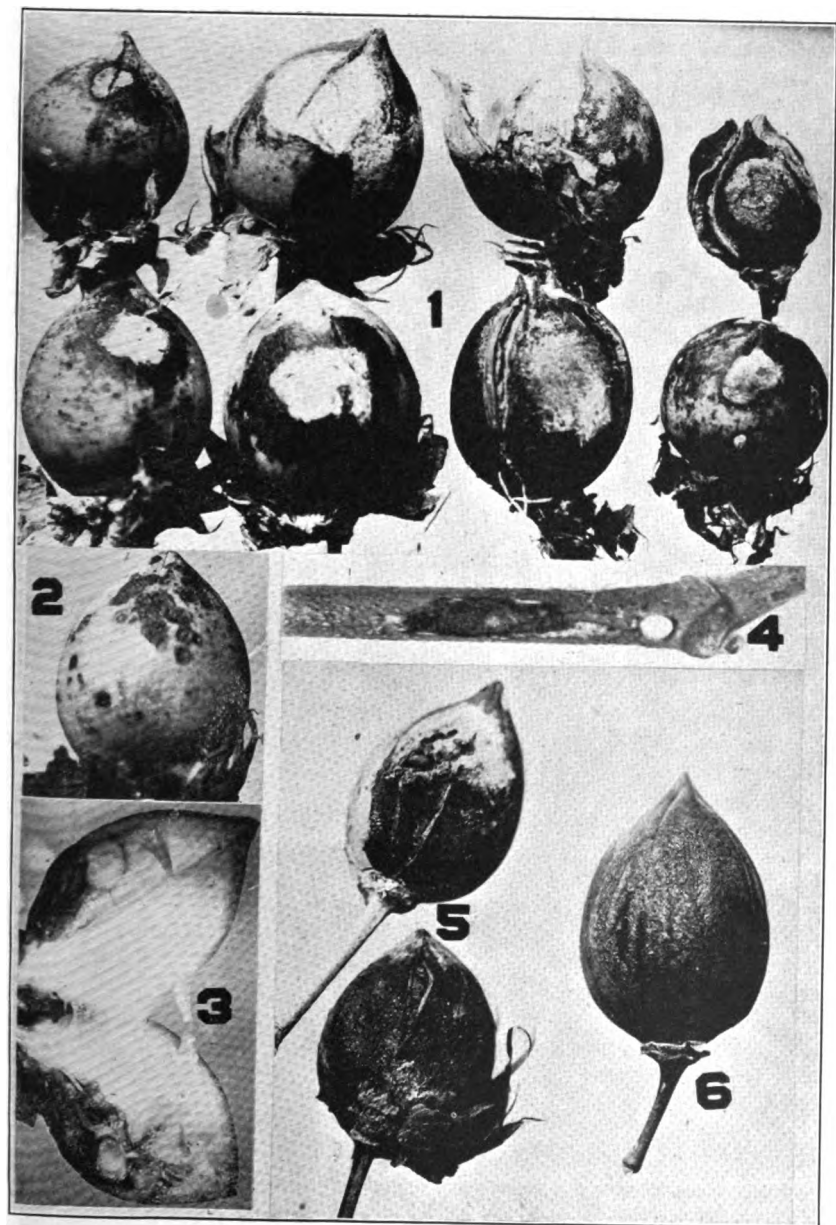


PLATE II.

## PLATE III.

1. Angular leaf-spot on leaves showing two types of injury.
2. Angular leaf-spot on squares and small bolls.
3. Angular leaf-spot on nearly mature boll. (Photo. by Hewitt.)
4. Angular leaf-spot spots on base of boll.
5. Delinting cotton seed with sulphuric acid to control angular leaf-spot and anthracnose. Five men working two days delinted 220 bushels of seed.

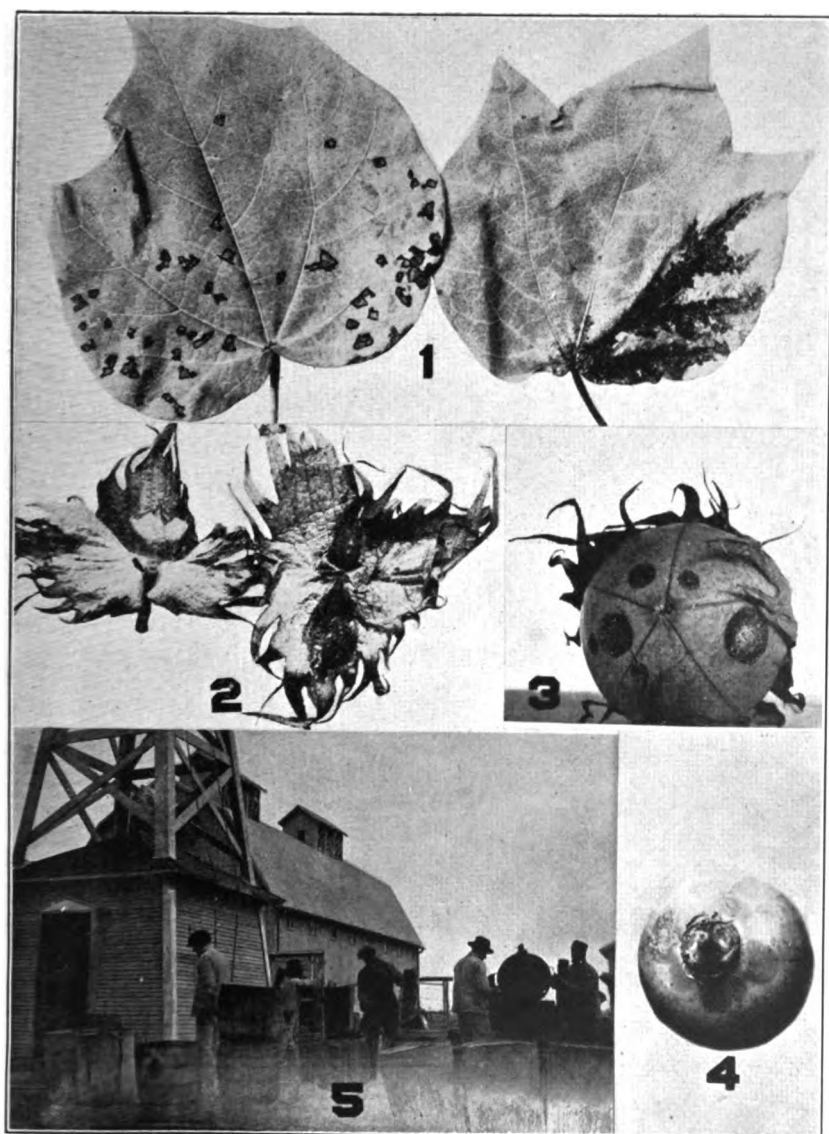


PLATE III.



**PLATE IV.**

1. A Logan County cotton field injured by Phoma blight. This field had about half a stand.
2. Phoma blight on stems of cotton. Natural infection.
3. Phoma blight on cotton boll. Artificial inoculation.
- 4 and 5. Check wounds on boll and stem.

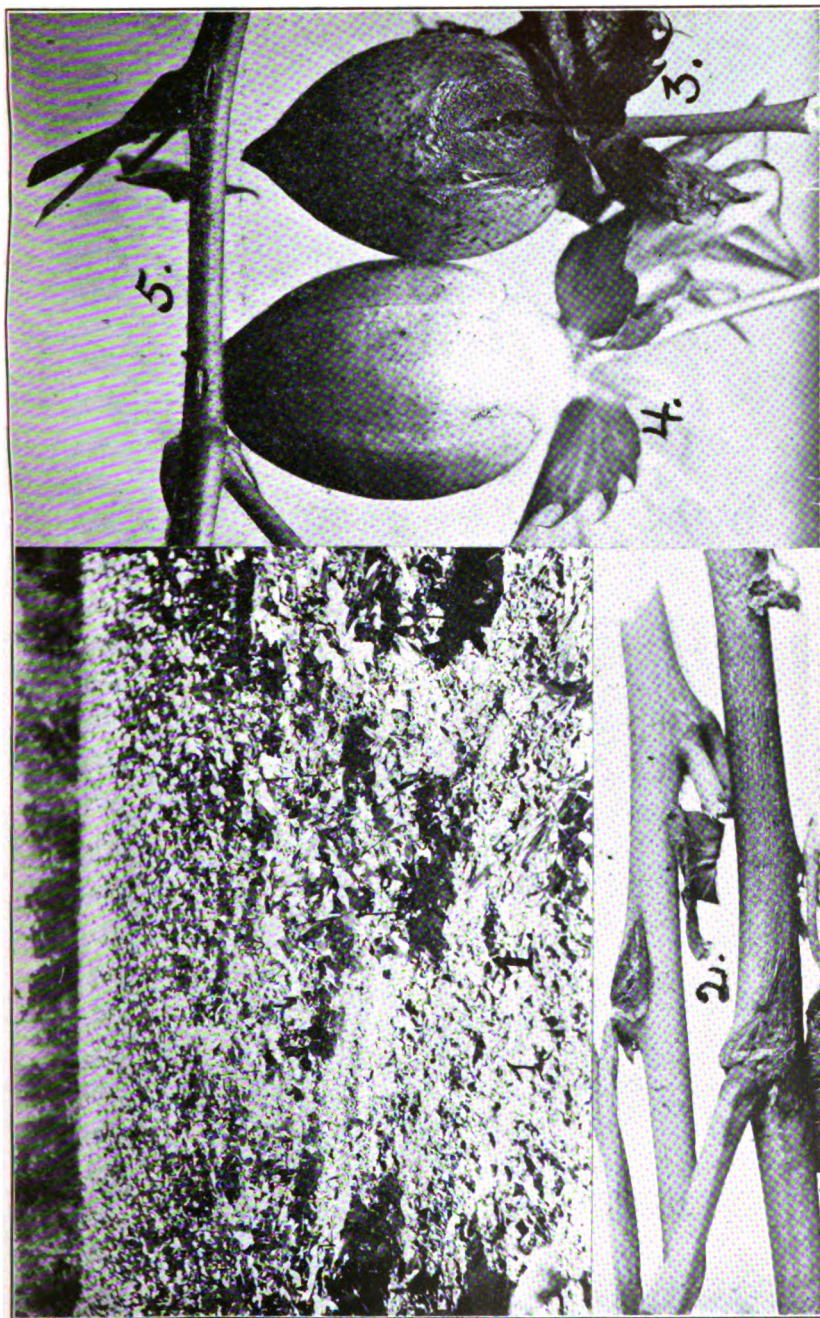


PLATE IV.

## PLATE V.

1. *Alternaria* Leaf-spot.
2. *Mycosphaerella* leaf-spot..
3. Sun-burn of cotton bolls. These bolls were not injured in any way by fungi or bacteria.
4. Root-knot.
5. Lightning injury. (Note that the stem has grown, while the root has not.)

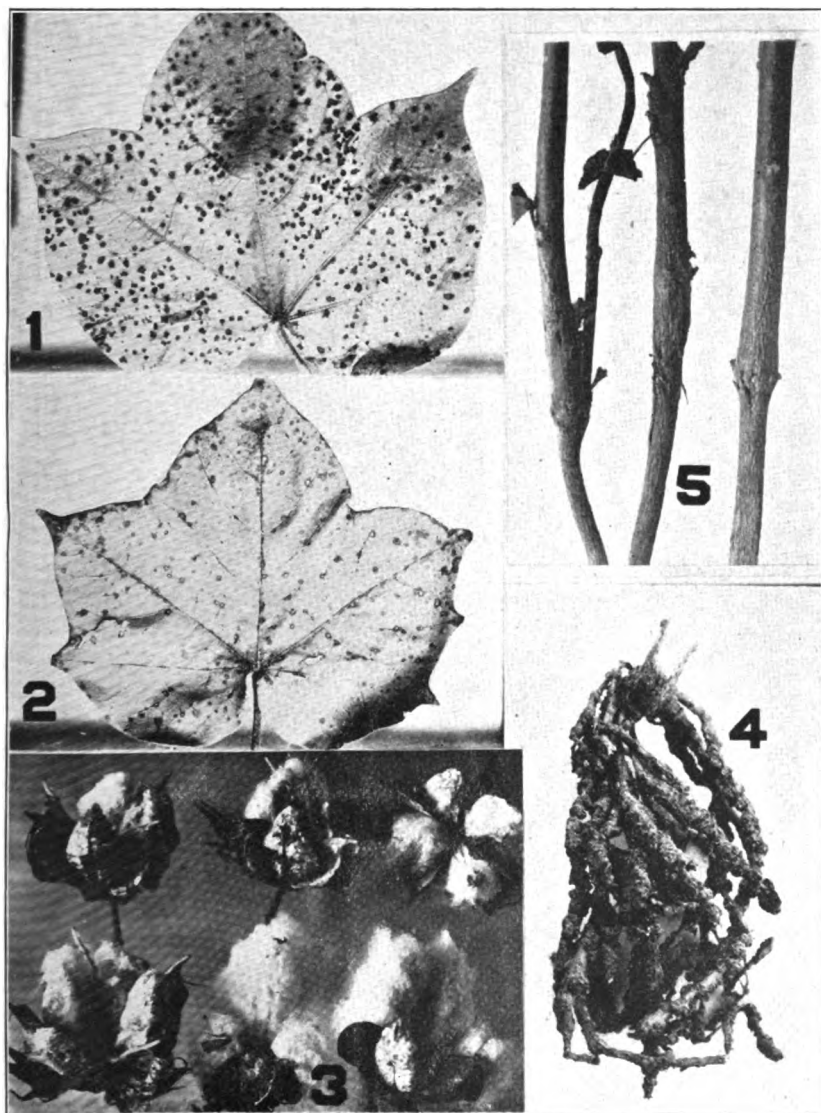
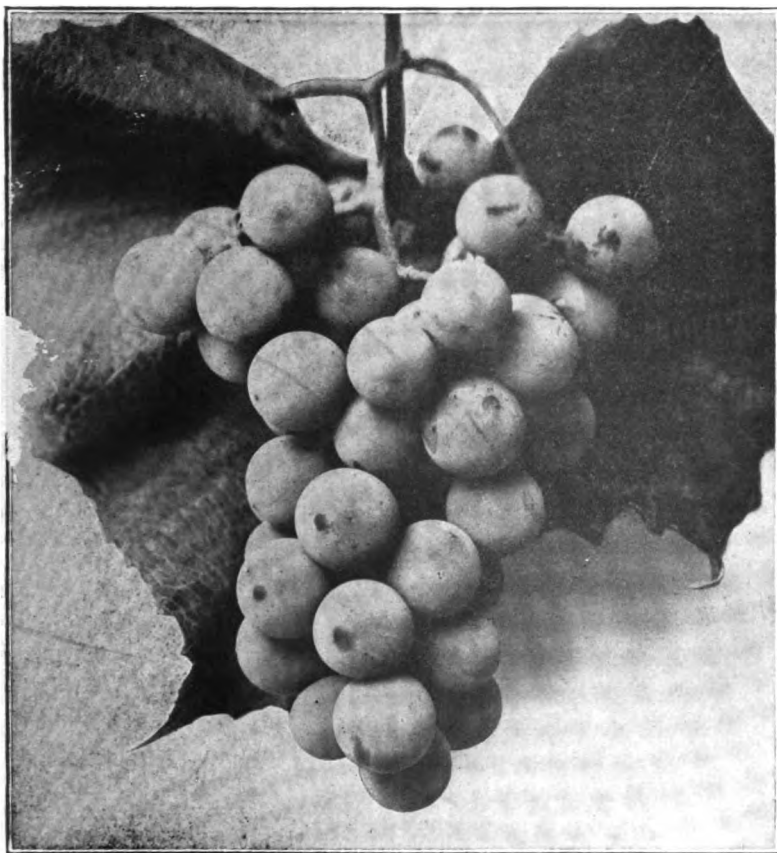


PLATE V.

### ACKNOWLEDGMENT

The writer is indebted to Dr. J. C. Jordan and to Prof. H. R. Rosen for reading the manuscript and making helpful suggestions and criticisms.

**UNIVERSITY OF ARKANSAS**  
**COLLEGE OF AGRICULTURE**  
**Agricultural Experiment Station**  
**COMMERCIAL GRAPE GROWING**



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# COMMERCIAL GRAPE GROWING

J. R. COOPER

## INTRODUCTION

The sandy soil and the genial climate of a large part of the state of Arkansas offer wonderful possibilities for grape growing on a commercial scale. The relatively high yields of well flavored fruit which are already being produced at several points in the state where vineyards receive only a minimum amount of attention is an indication of what may be expected when special care and intensive methods are used. Grape growing is already a major project at two points in the state—Tontitown and Altus—where very gratifying results are being obtained.

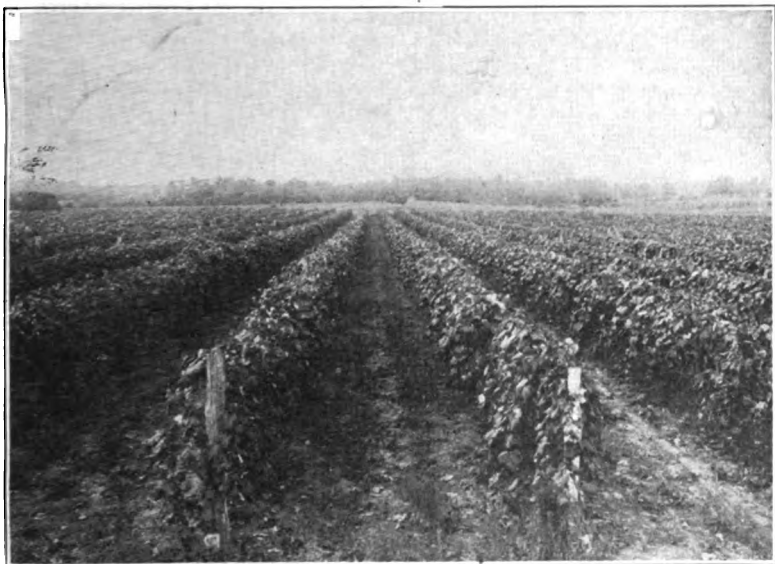


Plate I.—A representative Arkansas vineyard.

There is no other fruit crop which is more easily or satisfactorily handled from either the standpoint of production or disposition; and few give more satisfactory returns. The labor connected with the growing of a crop of grapes is comparatively light and comes at a time when other crops need little attention. There are a large number of farm projects with which the growing and handling of grapes will harmonize exceptionally well, from the standpoint of labor, in taking care of the crops. Pruning, which is one of the most time-consuming phases of grape culture, can be done during the winter months; cultivation can be fitted in



with the cultivation of other crops; and the grape harvest falls at a time, in this state, when other crops are not needing attention.

Grapes are now in heavy demand as a fresh fruit, and consumption, while much lower than it should be in comparison with other fruits, is rapidly increasing and can be expected to increase much more rapidly within the next few years. Large quantities of grapes are being used in manufactured products, and the grape juice industry is now assuming vast proportions. Only within the last few months arrangements have been perfected for the establishment of a large grape juice plant at Springdale in Northwest Arkansas.

### VARIETIES

While a great many varieties of grapes can be grown more

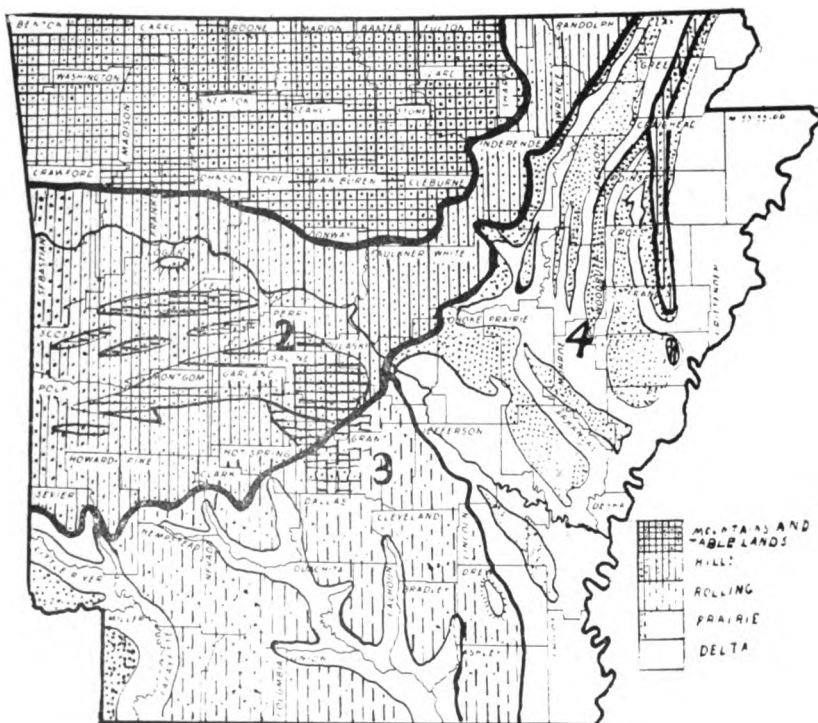


Plate II.—Regional map of Arkansas.

District 1.—Ozark Region.

District 2.—West Central Hills Section.

District 3.—Coastal Plains.

District 4.—Delta and Prairie Region.

or less successfully, in Arkansas, and should have a place in the home planting, or the vineyard planted for local or special market, very few have all of the qualities required of a good commercial grape. To qualify for this latter class a variety must be of high quality, productive, adapted to climatic conditions where it is to be grown, and to some degree disease-resistant, tho with the present development of disease control this phase of the question is of less importance than formerly.

The Concord is the standard grape for Arkansas conditions both for shipping and for the manufacture of grape juice. For the latter purpose some manufacturers will use no other variety, tho some others will accept Wodren.

In the following list a single star (\*) indicates that the variety so marked is recommended for home use only; a double star (\*\*) that it is recommended for home use and local and special markets; a triple star (\*\*\*) that it is a good commercial variety; and four stars (\*\*\*\*) that it is a variety used in the manufacture of grape juice:

| Variety          | Color         | Quality   | Date of Ripening | Districts of the State |      |    |    |
|------------------|---------------|-----------|------------------|------------------------|------|----|----|
|                  |               |           |                  | 1                      | 2    | 3  | 4  |
| Brighton         | Dark Red      | Very Good | Mid-July         | **                     | **   | *  | *  |
| Brilliant        | Dark Red      | Excellent | Mid-July         | **                     | **   | *  | *  |
| Campbell's Early | Black         | Excellent | Mid-July         | **                     | **   | ** | *  |
| *Catawba         | Purplish Red  | Very Good | Early Aug.       | **                     | **   | *  | *  |
| Concord          | Black         | Good      | Late July        | ****                   | **** | *  | *  |
| Delaware         | Light Red     | Best      | Mid-July         | ***                    | ***  | ** | *  |
| Hicks            | Black         | Very Good | Late July        | ***                    | **   | *  |    |
| James            | Black         | Very Good | August           |                        | *    | ** | ** |
| King             | Black         | Very Good | Late July        | ***                    | ***  | *  |    |
| Moore's Early    | Black         | Good      | Mid-July         | ***                    | ***  | ** | *  |
| Niagara          | White         | Good      | Late July        | **                     | **   | *  | *  |
| Scuppernong      | Whitish Brown | Very Good | August           |                        | *    | ** | ** |
| Worden           | Black         | Very Good | Mid-July         | ****                   | ***  | *  | *  |

\*Used in New York for the manufacture of red grape juice.

## SELF-STERILITY AND CROSS-POLLINATION

Many varieties of grapes are partially or wholly self-sterile; that is, they will produce only loose, ragged bunches or no fruit at all when planted alone. Even the varieties which are classed as self-fertile often bear more abundantly and have more compact bunches when planted near enough to other varieties, blooming at the same time, to permit cross-pollination. Fortunately our most desirable varieties, such as Concord, Warden, Moore's Early, Delaware, Brilliant, Catawba, and Niagara are nearly or wholly self-fertile. Lack of fertility in the soil, poorly drained soil, poor air drainage, and improper or insufficient pruning may help to cause loose bunches and light crops.

## LOCATION AND SITE

Temperature is a very important factor in grape growing. Grapes give more satisfactory results where the temperature is fairly low and comparatively even during the early part of the growing season. Warm days, however, with abundance of sunshine, and cool nights are desirable during the maturing season. The amount of rainfall is also an important factor. While grapes do not require a large amount of water for good growth, any lack of moisture during the growing season is reflected in the crop production. On our well drained soils there is little danger of having too much water except where the vineyards are situated on low land. For best results grapes should have a dry season in which to mature their fruit. Too much wet weather during the time when the fruit is maturing is often disastrous to both quantity and quality of the crop. An excess of moisture keeps the vines growing too long and may cause an uneven ripening of fruit. At the same time it encourages fungous diseases.

Danger from frost is usually less on high land, and, while grapes usually bloom late enough to escape serious frost injury, there is still some danger of a partial loss of crop from this factor. Low places are usually not only colder and more subject to frost injury in the early spring but are also subject to more disease injury during the growing season than are slopes or hilltops. For these reasons low lands should be avoided unless proper water and air drainage can be secured. On the other hand, land which is too steep is not desirable for vineyard purposes on account of the difficulty of cultivation and other vineyard operations.

Unless the slope is pronounced little attention need be paid to its direction. Some of our southwest slopes sometimes suffer from high winds in the early part of the season, and there is sometimes a little more sun-scald than on level land or land sloping in other directions. Any danger of sun scald can, however, be avoided by proper planting, cultural methods, and the use of shade crops.

## SOILS

The grape has long been known as the "poor man's crop" and a great deal has been said in regard to its performance on poor soils. In fact many people believe that very poor soils, from the standpoint of ordinary crops, are the most desirable for grape growing and that good soils should never be planted to vineyards. The grape, however, responds to good soil as readily as any other crop and is as cosmopolitan in its requirements and adaptations as any other fruit grown. We find the grape thriving on soils ranging all the way from light sandy loams to heavy clays.

More failures can be traced to poor air and water drainage than to improper soils. Poor cultural methods, including lack of cultivation and improper pruning and training, go a long way toward making a vineyard unprofitable, whereas, contrary to the general belief that grapes must be grown on poor soil, lack of soil fertility and humus are often the factors which convert an otherwise profitable vineyard into a liability.

There are some regions in the grape-growing belt where the soil is so full of small flinty rocks that general farming is impracticable. Such stony lands will render good returns from grapes only when the soil is so deep and loose that the roots can penetrate it, and then only when plenty of plant food and humus are added. But while stony soil will render good returns, when given the best of care, we cannot hope for them to produce as much as deep rich loam soils. Grapes should never be planted where cultivation is impracticable.

### PREPARATION OF SOIL

For best results, soil on which grapes are to be planted must be well supplied with plant food and must be put in good physical condition by having plenty of humus incorporated in it. Such soil can be had only by using new land or, in the case of cropped land, by building it up with manure, or fertilizers and green manuring crops; sometimes by a combination of all three.

One difficulty in providing proper soil on which to make a planting is that the grower makes up his mind only at the last minute, to plant a vineyard and after making up his mind finds that he cannot wait a year to prepare the soil. In such cases, where planting is done on old land, the best results will be obtained only by the use of fertilizers or manure in conjunction with a well-planned cropping, or rotation, system in which some legume such as cowpeas, soy beans, or clover is used as a summer crop, followed, in the case of cowpeas or soy beans, by some such crop as rye for a winter cover. It is of course necessary where the land has been badly depleted of nitrogen to add at least this element, in the form of commercial fertilizer, until the deficiency can be made up by growing crops. It will also often be necessary to add phosphorus before good results can be had from clover.

Thoro plowing and preparation are a necessity. The land should be plowed deep before time to set the plants and thoroly pulverized and worked down.

### STOCK

Only vigorous, disease and insect-free stock should be used. The vineyard is a long-time crop. We expect it to stand from

forty to fifty years. We can then not exercise too much care in the selection of plants. Well rooted, one-year-old plants are the most desirable. Plants older than two years are undesirable because they do not respond and grow as readily as younger plants and the mortality is high. Such plants are often those which have been culled from the nursery the year before because of poor growth. Nothing is gained by planting stock more than two years old even when it is not stunted, since the top is cut back to two or three buds and the roots are cut back correspondingly. Cheap plants of any variety are usually more expensive in the end than high class material. A vigorous one-year-old grape plant should have one or more canes three to five feet long with several vigorous branches and a correspondingly heavy root system. When these plants are dug most of the top is cut away and the roots trimmed. In ordering plants from the nursery only those showing a good heavy cane and a large number of well formed roots should be accepted. When received from the nursery the bunches should be opened and the plants carefully heeled in so that the damp soil will come in contact with the roots of each individual plant. If the bunches are not broken the roots will often heat and dry out to such an extent that the plants are rendered worthless. Such heating with the consequent injury often occurs in transit where a large number of plants have been carelessly packed in a car without proper ventilation.

### HOME PROPAGATION

Under normal conditions it is usually cheaper and more satisfactory to buy plants from a good reliable nursery firm than it is to produce them at home. There are, however, several advantages in home-grown stock. Only the most vigorous plants should be used. They can be dug and transplanted at any time and are always available for making resets. It is a good plan, even where stock is bought from the nursery, to have a few plants growing each year for resets. In the propagation of cuttings only one-year-old wood should be used. Both very weak and very rank growths should be avoided. It is best to use moderately heavy canes with joints of medium length. For best results under Arkansas conditions cuttings should be made rather long so that when planted the lower end will be in moist soil. A cutting of proper length will usually consist of three or more eyes, and be 12 or 14 inches long. The cut at the lower, or large, end should be made close to the bud (within one-half inch) to insure a good growth of roots. The cut at the small, or top, end is usually made one and one-half to two inches above the bud to prevent injury by drying out.

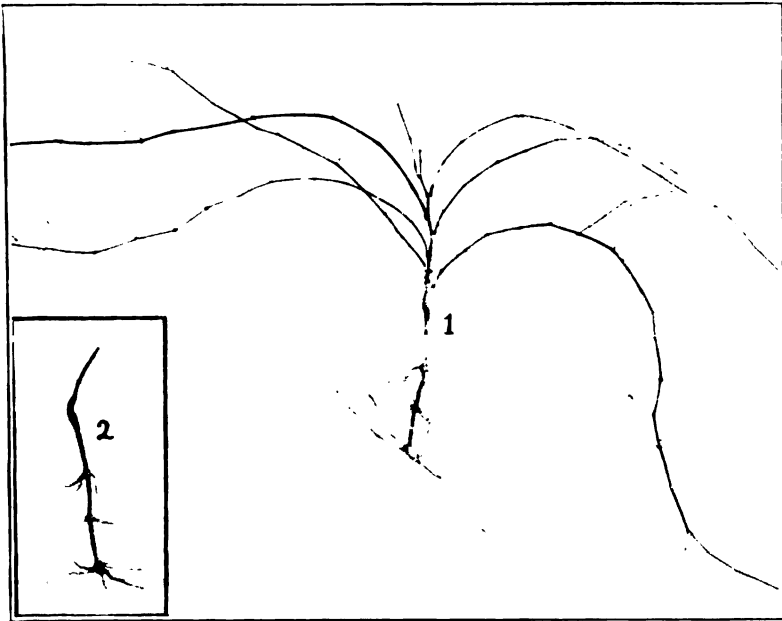


**Plate III.—One-year-old rooted grape cutting.**

- 1.—Plant as it came from the nursery row.
- 2.—Same plant trimmed ready for setting.

The cuttings may be made at any time after the leaves have fallen, but it is usually best to make them early in order to avoid winter injury to the wood and to allow plenty of time for the ends to callus. Cuttings should be tied up in bundles of 25 to 50 with the butts even, and all at the same end of the bundle. Select a warm, well drained spot and bury the bundles with the butt end up about five or six inches below the surface of the ground. By allowing them to remain here until spring, the butt ends being in warm soil, will callus and be ready to form roots while the top ends being in cooler soil will not start. As soon as the soil can be worked readily in the spring the cuttings may be "lined out." (This is done by making a deep furrow in well prepared soil and setting the cuttings against the steep side of the furrow three to six inches apart. Enough soil should be tramped around them to hold them upright. The rest of the soil may be thrown back by a plow or cultivator. The soil should be firmly packed and the cuttings should be placed deep enough so that after the soil settles the top bud will be just above the surface. Unless the soil

where the cuttings are "lined out" is moderately rich a light dressing of nitrate of soda, after the growth is well started, will be beneficial.

### TRANSPLANTING

The vines may be dug and transplanted at the end of the first season, any time after the leaves fall, or they may be cut back to two buds and allowed to grow another year. Only the most vigorous should be used. Plants which make only a very light growth the first year should be discarded. Such plants will often make a fair amount of growth the second year, and many nursery firms follow the practice of keeping over the weak growing plants and selling them, the second year, for one-year-old stock, but they will, as a rule make a poor showing in the vineyard.

### LAYING OUT THE VINEYARD

If the vineyard is to be planted on fairly level land the rows should be laid out straight. Rows running east and west provide the fullest exposure to the sun, while rows running north and south afford more shade to the fruit during the hottest part of the day and allow an equal amount of light for both sides of the row. Under Arkansas conditions rows running north and south are more desirable. The direction of the rows, however, is most often determined by the shape of the field which will be used for the vineyard. The contour of the land is also a factor which should always be considered in laying out rows. On land where there is a decided slope the rows should follow the contour of the land, or run crosswise of the slope, in order to prevent soil erosion.

For convenience in operations alleys sufficiently wide to permit the passage of wagons and machinery should always be provided in a vineyard where the rows are long. On hilly lands the position of these alleys will be determined more or less by the lay of the land. On level lands they are usually placed at regular intervals. Where the rows are planted ten feet apart it will usually not be necessary to leave alleys running lengthwise of the field but cross alleys should be made at frequent intervals to avoid long hauls of brush at pruning time, and fruit at harvest time. In practice it has been found convenient to have the rows not longer than four or six hundred feet without a cross-alley.

### PLANTING

If the land has been properly prepared and the plants are in good condition the operation of planting is not a heavy task. The petting and pampering of plants in setting is largely overdone. With the soil in good condition no watering will be necessary. Puddling the roots is likewise needless. It is, however, practic-

able to haul the plants to the field in a tub of water and use them from this as needed. On the other hand one should not approach the task too lightly. The holes need be only large enough and deep enough to hold the trimmed roots without cramping. On well prepared land where the rows have been marked off by a plow, it will be necessary to remove only one or two spadefulls of earth to make a sufficiently large hole. With some soil placed about the roots in the bottom of this hole and well "firmed" by tramping, and the remainder thrown back into the furrow by a plow, the plants will be well set. Time may be saved in setting large acreages if the men work in gangs. An arrangement which is often advised is to have one man dig the holes, while a second trims the plant and puts it in place, and a third covers. It has been the experience of the writer, however, that two men will do about as much as three, and that one good man can get along very well alone. The plants should be set so that only the buds will be above the surface when the soil settles.

**Planting Distance:** There is considerable variation in the width of rows and the distance apart at which plants are set in different regions. The spacing of plants is modified by both soil and climatic conditions. Plants require more feeding room for the root system on light than in heavy soils. More distance is also required in regions where there are considerable rain and cloudy weather. As a rule the warmer the climate or the exposure the greater should be the distance between the vines. Cultural methods and machinery used will also have some bearing. Rows may vary in width from eight to ten feet and plants may be set from six to ten feet apart in the row. Vineyards with the plants set eight feet apart each way are giving excellent results. In others we find that rows ten feet apart and plants six to seven feet apart in the rows are very satisfactory. The writer is partial to the rows not closer than ten feet, when apples or peaches are being grown on the same farm, in order to permit the use of orchard machinery in the vineyard. When the rows are this wide the plants may be put eight feet apart in the rows and still have ample room to develop.

Plants required for an acre at given planting distances:

| Width of Row | Distance Apart of Plants | No. Plants |
|--------------|--------------------------|------------|
| 8-----       | 6-----                   | 907        |
| 8-----       | 7-----                   | 777        |
| 8-----       | 8-----                   | 680        |
| 8-----       | 9-----                   | 605        |
| 8-----       | 10-----                  | 544        |
| 9-----       | 6-----                   | 806        |
| 9-----       | 7-----                   | 691        |
| 9-----       | 8-----                   | 605        |



|    |       |    |       |     |
|----|-------|----|-------|-----|
| 9  | ----- | 9  | ----- | 537 |
| 9  | ----- | 10 | ----- | 484 |
| 10 | ----- | 6  | ----- | 726 |
| 10 | ----- | 7  | ----- | 622 |
| 10 | ----- | 8  | ----- | 544 |
| 10 | ----- | 9  | ----- | 484 |
| 10 | ----- | 10 | ----- | 435 |

**Marking Out:** There are several different methods of marking out, or laying off, the field for planting. Most of those which are recommended are attended with more or less difficulty, and as a rule the grower will be better satisfied with a method of his own. One of the most satisfactory ways of laying out a field for planting is to set tall stakes, and with a turning plow or marker, to run straight furrows across the field in both directions. The holes for the plants can then be dug where the furrows cross. By sighting back when setting, the rows can easily be made straight. Laying out the field with a plow reduces to a large extent the labor of digging holes. It will be necessary to remove only a small amount of soil for setting and after the plants have been properly placed enough soil can be thrown back with the spade to hold them in place and the remainder of the soil can then be thrown back with the plow.

### THE TRELLIS

In order to distribute the fruit and foliage so that the maximum benefit from air and sunlight may be had it is necessary to have a support for the vines. A wire trellis has proven most economical and satisfactory for this purpose. A well built, substantial trellis permits the fastening of the vines in a systematic manner keeps the fruit off the ground, distributes it so that it is properly exposed to both air and sunshine, and facilitates the gathering of the crop. The style of trellis will depend somewhat on the system of training followed. For the Four-cane Kniffin System a two-wire trellis will be sufficient, but where the Recurved-fan System of training is used a three-wire trellis will be found more desirable, since it offers better opportunity to properly train and tie the new shoots. Number 10 or 12 smooth wire is usually used. Larger wire is sometimes used but it is more difficult to handle and is more expensive while the No. 10 or 12 wire is sufficiently strong to hold up the load. The amount of wire needed to trellis an acre of grapes with rows 435.5 ft. long and ten feet apart can be determined from the following table:

| Size of Wire | Feet per Pound | Amount Necessary for |                    |
|--------------|----------------|----------------------|--------------------|
|              |                | Two-wire Trellis     | Three-wire Trellis |
| No. 9        | 17.9           | 500 lbs.             | 750 lbs.           |
| No. 10       | 22.3           | 400 lbs.             | 600 lbs.           |
| No. 11       | 27.3           | 320 lbs.             | 480 lbs.           |
| No. 12       | 34.3           | 254 lbs.             | 381 lbs.           |

In building a trellis good strong posts should be set at the ends and firmly braced. Intermediate posts should be set about every sixteen to twenty-four feet or two or three times as far apart as the vines stand in the row. The posts should stand about five to five and one-half feet above the ground and should be set in the ground at least eighteen to twenty-four inches.

The wire should be attached to the end posts in such a way that it can be easily tightened or loosened. This is done in some instances by means of metal ratchets and in others by means of wooden spools or blocks. The most common method, however, is to draw the wire tight with a stretcher, pass the free end around the posts, and wrap it. The wire should be stapled loosely to the intermediate posts in order to facilitate taking up slack.

The vines should be fastened to the windward side of the trellis with twine or soft wire so that the force of the wind will

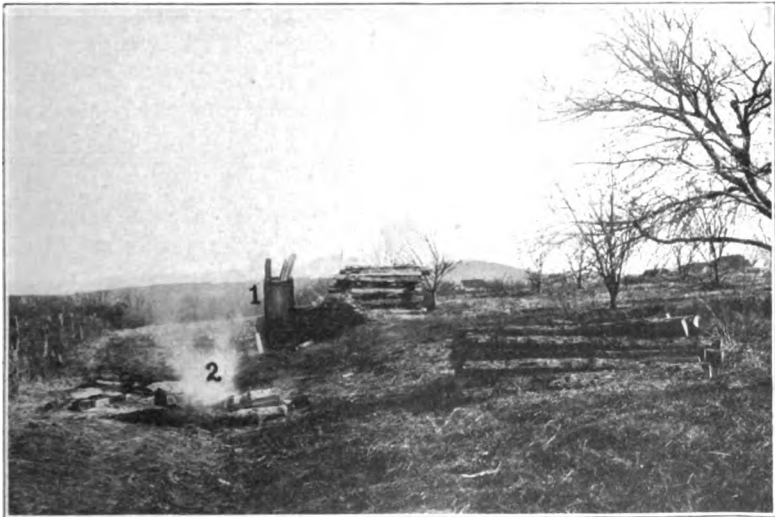


Plate IV.—Treating trellis posts.

1.—Galvanized steel tank with fire box below.

About 20 posts can be treated at one time.

2.—Charring the posts in an open fire before immersing them in creosote.

push them against the wire rather than tear them away.

Steel posts are the most desirable for trellises, but present prices are prohibitive. Wood posts are very satisfactory where properly treated to prevent decay. Untreated wood posts rot very quickly and must be replaced at frequent intervals. Posts which have been peeled and seasoned will last much longer than green posts. The most satisfactory method of preserving posts is to treat them with creosote. This can be done economically by immersing the lower part of the posts for thirty minutes to an hour, in creosote which is kept at or near the boiling point. This can be done by making a furnace or fire box beneath an upright galvanized tank, containing enough of the preservative to reach a desired height on the posts. For the best results the liquid should be allowed to cool before the posts are removed. This consumes a great deal of time so where a large number of posts are to be treated a separate cooling tank, containing cold creosote, into which the posts may be put after they are taken from the heating tank, will facilitate matters. A fairly good job of preserving can be done by simply keeping the posts immersed in the hot creosote for the specified length of time and then piling them up to dry. The best method, however, of treating posts when only one tank is available, is to char the butts before putting the posts into the tank. This can be done without taking extra time for the operation since the operator can char one batch of posts while another is being heated. Charring alone does not increase the life of the post.

### FRUITING HABITS OF GRAPES

Grapes differ from the tree fruits in their fruiting habits in that the fruit is born upon shoots which grow from year-old canes. Theoretically each bud left on the one-year-old wood will produce a shoot. All of these shoots, however, do not produce fruit. The shoots which come from the buds on the short jointed canes are the fruit bearers and will produce from one to five clusters each. The basal bud often produces wood only and long-jointed, heavy canes are often barren. It is a very easy matter for an experienced vineyardist to make a close estimate of the following season's crop and to determine, by observing the vigor of the vine, the kind and amount of pruning which is necessary. Twenty to thirty vigorous buds will usually produce all the fruit and the new wood which an average vine should be allowed to bear. In early winter pruning, however, it is often a wise practice to leave thirty to forty or even more buds since more are liable to be injured by cold weather during the winter. The excess buds may be removed the next spring. The paramount object in pruning is to secure the maximum amount of good fruit and at the same time to maintain a strong healthy plant. When the vine

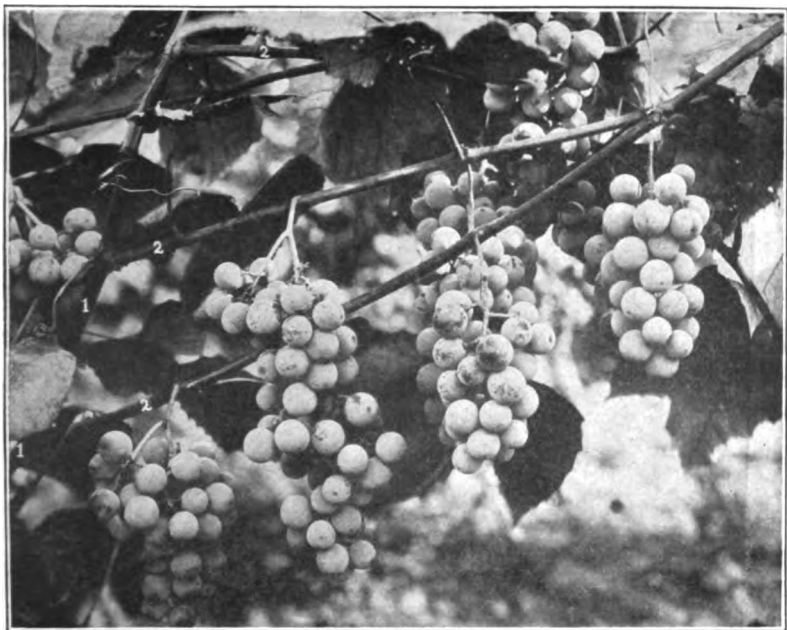


**Plate V.**—Illustrates the fruiting habits of grapes.

- 1.—One-year-old fruiting cane left at pruning time.
- 2.—Fruiting shoots which grew from the buds or "eyes" on this cane during the current season.

becomes too vigorous, growth must be retarded by leaving more wood. On the other hand vines making little growth must be pruned more heavily. In cases of badly diseased vines, vines which have been badly injured by insects, or vines making poor growth on account of poor soil conditions, it will be necessary to remove all but a very few buds and throw a large part of the energy of the plant into the production of wood instead of fruit. Old vines must often be pruned heavily to rejuvenate them. Vines growing on rich heavy soil will not bear as much pruning as those growing on light sandy soils. The fruit is, as a rule, larger and later on heavily pruned vines than on those receiving less pruning. Where a large amount of old wood is left on the vines there is considerable danger of uneven ripening of the fruit.

#### PARTS OF THE VINE DEFINED

A clear understanding of the different parts of the vine is necessary before the details of pruning and training can be satisfactorily considered.

The *trunk*, or *stem*, is that part of the vine between the roots and the branches.

A *branch* is the portion of the vine connecting the arms with the trunk or stem and is usually several years old. The terms *branch* and *arm* are more or less interchangeable.

An *arm* is a portion of the vine more than one year old but usually not as old as the portion which is termed a *branch*.

A *cane* is a portion of the vine which was produced the previous season.

A *shoot* is an immature or growing portion of the plant.

*Laterals* are the secondary shoots or shoots from shoots.

A *spur* is a cane pruned back to two or three buds.

A *basal bud* is one at the point where the cane grows from older wood.

### PRUNING AND TRAINING YOUNG VINES

The general vigor and productiveness of a vineyard are determined largely by the treatment that the vines receive in the matter of pruning and training. There is no other among all of our cultivated fruits which will respond so readily either favorably or unfavorably to the treatment received. Early training is of the utmost importance. Where proper training has not been given in starting a vineyard it often becomes necessary to start all over again with new plants or at least it will be necessary to cut off all of the old wood and start with new shoots from the roots.

Grapes are cut back to not more than three buds at planting time and the new shoots allowed to grow at will during the first season.

At the end of the first season or before growth starts the next spring, all of the canes are cut away except one and this is again shortened back. Plants which have made little growth are cut back to only two or three buds, while stronger growing plants may be left as high as the lower wire. Only in cases of exceptional growth should the cane be left long enough to reach the top wire of the trellis. The cane and new shoots are tied to the trellis or to upright stakes. Many growers do no pruning during the second season but there is a well founded belief, borne out by our own experience, that better shaped and more vigorous plants will result by pruning to one or two of the strongest shoots and tying these to the trellis or stakes. Some growers go even further than this and pinch off the ends of these shoots as soon as they reach the proper height for heading. This depends, of course, on the system of training to be followed.

**Kniffin System.** Where the Kniffin System of training is adopted the end of the shoot is pinched off as soon as it reaches the height of the top wire of the trellis. If the Recurved-fan

System is to be followed pinching is done when the shoot reaches about the height of the lower wire. This causes numerous laterals to form. With the Kniffin System of training no buds are allowed to develop except near the upper and lower wires. With the Fan System no buds are allowed to develop except in the neighborhood of the lower wire, all of the others being broken off as soon as growth starts.

At the beginning of the third season, at least, it will be necessary to choose the system of training which is to be followed and to erect a permanent trellis in order to train the plants properly. If the Kniffin System is followed, pruning at the end of the second year will consist of removing all but one healthy cane and cutting this cane just long enough to tie to the top wire of the trellis. In vineyards where summer training is practiced this will already have been done. All except two of the laterals at each wire should be removed and these two cut back to not more than two buds. The canes should be tied securely with twine or soft wire to both wires in order to maintain an upright position but they must not be tied tight enough to hinder growth. During the third season new shoots will be produced at the joints, or "eyes," of the canes which are left. All of the shoots which form above the lower wire may be allowed to grow but those below the lower wire should be pinched off as soon as they start. Stronger and more vigorous shoots will result if none are allowed to develop except in the neighborhood of the upper and lower wires. Where the shoots are not kept pinched off during the growing season considerable pruning will be necessary the following fall. All but four of the new canes must be removed. One of these should be trained in each direction on either wire. A well pruned vine at this time will have one cane five or six buds long, running in either direction on the upper wire and similar shoots running in either direction on the lower wire.

Some growers prefer to train to the "Y" Kniffin. In this system one branch of the main trunk is trained to the lower wire and canes are taken from this to run in either direction. The other branch of the trunk is led to the top wire and canes for the top wire are procured from this.

Still others train to what is known as the Two-trunk Kniffin, in which one trunk is trained to the lower wire and another trunk to the top wire. Regardless of which system is used the principles of pruning and renewal remain the same. The general experience of growers has been such that only the Four-cane Kniffin System with a single stem is recommended.

**Recurved-fan System:** In training to the Recurved-fan System the pruning at the end of the second season will consist of removing all but one good strong cane and cutting this off at



Fig. 1



Fig. 2



Fig. 3

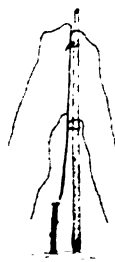


Fig. 4

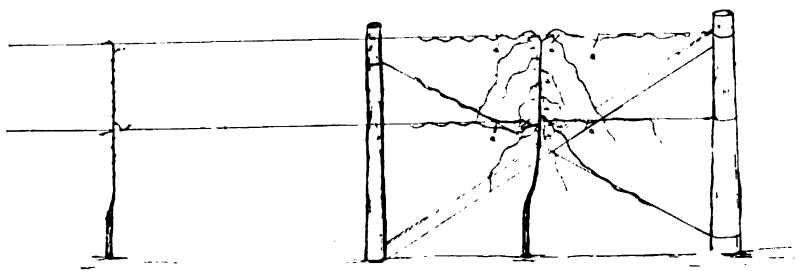


Fig. 5

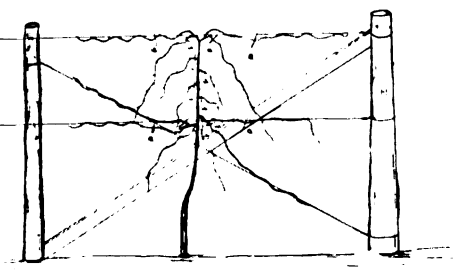


Fig. 6

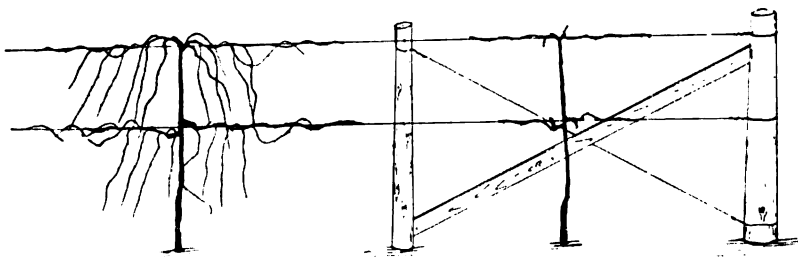


Fig. 7

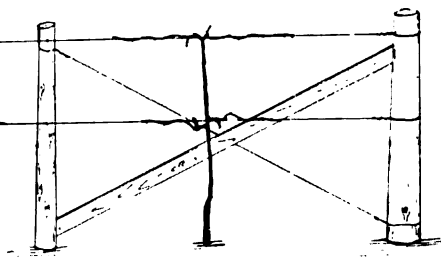


Fig. 8

# Plate VI.—

- 1.—Illustrates a young grape plant pruned at setting time to only three buds.
- 2.—Illustrates a similar plant at the end of the first season.
- 3.—Illustrates the way a plant should be pruned at the end of the first season.

- 4.—Illustrates the treatment of a plant during the second season. Note that only one cane has been allowed to develop. The top of this cane was pinched off to induce shoots to form and only four of these shoots were allowed to grow.
- 5.—Illustrates the pruning such a plant should receive at the end of the season.
- 6.—Illustrates the growth of the plant during the third season. A light crop of fruit can be expected the third year. The amount of pruning necessary, and places to make the cuts are indicated by the marks across the canes at "a."
- 7.—Illustrates a mature grape vine, trained to the four-arm Kniffin system before pruning.
- 8.—Illustrates a similar vine after being properly pruned.

about the height of the lower wire. Where summer pruning has been practiced this will already have been done. Usually several laterals will be present. Four of these are left but cut back to one or two buds. During the growing season all shoots should be removed from the lower part of the cane and, as with the Kniffin System, only those which are desired for future canes allowed to grow.

At the end of the third season pruning will consist of the removal of all but four canes which have been allowed to form near the lower wire and cutting these back to five or six buds each. Two of these canes should be tied to the middle wire and two to the lower wire. As shoots develop from these short canes, some of them should be trained to the top wire and some to the middle wire, allowing the ends to curve back.

By the end of this season the plants will have become vigorous and the canes long enough so that the regular Recurved System of training may be followed. This consists in removing all but four vigorous canes and four spurs of two buds each, one located near the base of each cane. Two of these canes should be trained up over the top wire and curved back to the middle wire and tied. The other two should be trained up over the middle wire and tied to the lower wire. This gives a good distribution of both foliage and fruit the following year.

### PRUNING BEARING PLANTS

The pruning of bearing plants consists of removing all wood which is weakened by age, disease, or insects, and in maintaining the amount, position, and vigor of new or fruiting wood by a proper system of renewal. The principles of renewal are essentially the same for all systems of training. *Renewal* means the annual replacing of old wood by new for the purpose of procuring fruit. Unless annual renewal is practiced the bearing part of the vine grows farther away from the roots; the bunches of fruit



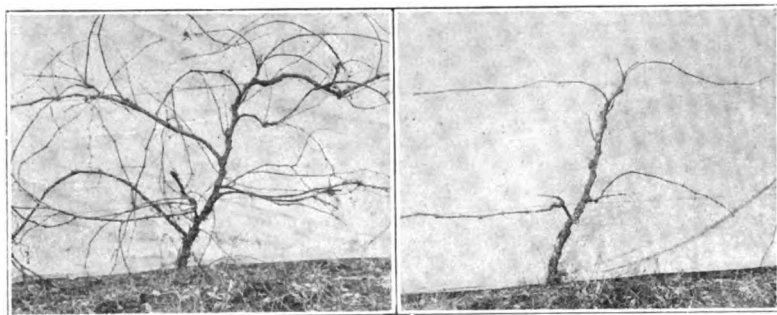


Plate VII.—Illustrates a mature grape vine, trained to the Kniffin System, before and after pruning. Note the amount of wood which has been removed. Not enough wood was removed at the previous pruning.

grow smaller and fewer each succeeding season; and the different parts of the vine deteriorate with age or may be injured by insects or diseases. An excess of old wood often causes the crop to ripen unevenly. Even where the crop ripens satisfactorily the maintenance of an excess of old wood in the vineyard means a reduction of the crop. Since fruit is produced on shoots from one-year-old wood, canes for fruit bearing must be renewed each season. Canes which originate close to the main trunk should be chosen. In order to furnish such canes short spurs are left, usually one spur for each cane, and these spurs are chosen

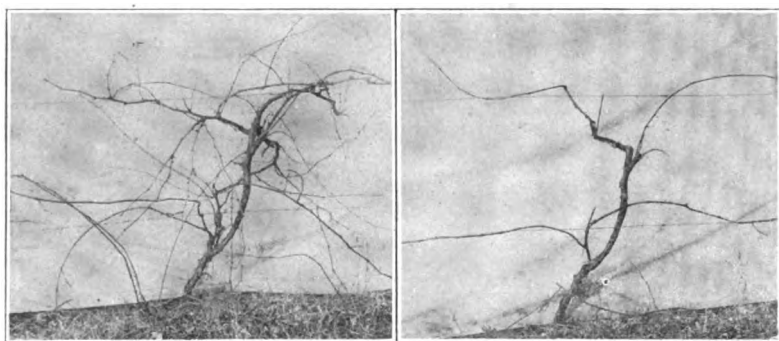


Plate VIII.—Illustrates a mature grapevine before and after pruning. This plant has had little previous training other than the removal of a certain amount of wood. An attempt is now being made to train it to the Kniffin System.

as close to the old trunk as possible. Desirable canes often arise from the basal bud of the cane which is left to bear fruit, but this cannot always be depended upon to furnish vigorous canes; therefore the spurs for renewal should not be overlooked. The canes from renewal spurs are as a rule more desirable since they will usually be more vigorous than canes arising farther away from the trunk. A healthy, vigorous plant will require from twenty to thirty buds to produce its crop of fruit and foliage for the following year. In order to insure as many buds as this, it is usually wise to leave thirty or forty buds when pruning is done early in the season. If all the buds go thru the winter it will be an easy matter to reduce the number before growth starts in the spring.

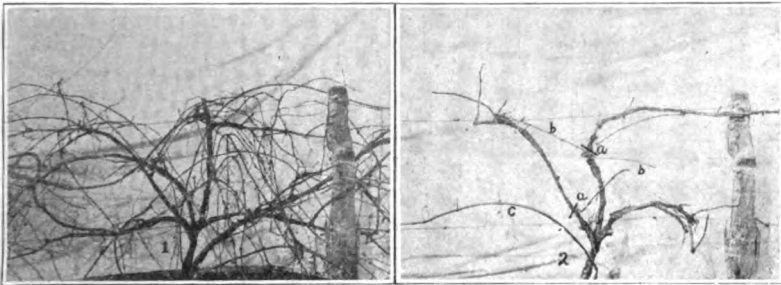


**Plate IX.**—Illustrates a mature grapevine before and after pruning, where no definite system of training has been followed. Too much old wood has been left during past years as well as at the present pruning. In Fig. 2 the old wood should have been cut away at *a* and the canes at *b* left longer. The bull cane at *c* should be tied upright to the top wire to be trained into a new trunk.

Grape pruning should not be looked upon as a job only for an expert. Any one can do it. Neither should the pruner attempt to prune every plant to look just like its neighbor. It cannot be done. What he should try to do is to have the right amount of new wood on each plant and have it in as nearly the right position as the growth of the vine and other conditions will permit.

## PRUNING DIRECTIONS

### Kniffin System

1. Save a strong cane on each side of the vine as near the top wire as possible.
2. Cut these canes about three feet long. Be sure that the tip end of each cane saved is alive.
3. Leave a short spur for each cane, preferably between the

cane and the trunk. If this is not possible choose the closest cane on the outside and cut it to a spur.

4. In case there is no desirable cane available for a certain position, save enough spurs to provide the desired number of buds to take the place of the missing cane.

5. Go thru the same procedure in pruning to provide fruit-

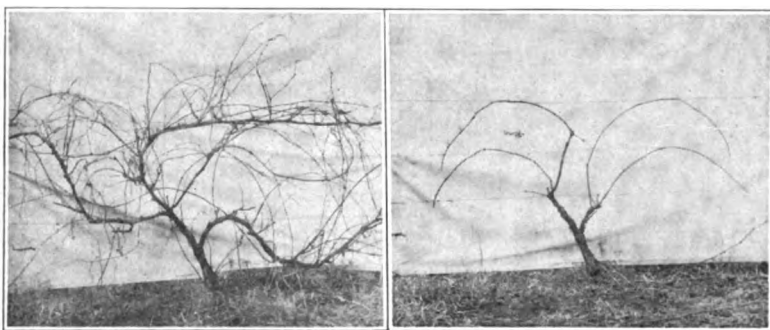


Plate X.—A mature grapevine before and after pruning, trained to the Recurved-fan system. Here again too much wood was left at previous prunings but the evil is remedied in the present pruning.

ing wood for the lower wire but cut the canes shorter—about eighteen inches to two feet.

6. Make cuts, in pruning canes, about one inch beyond the last bud.

7. Renew any weakened parts of the vine by training a new shoot or cane to fill its place. When a desirable cane is procured, cut away the old part the next time the vine is pruned.

8. Renew the trunk in the same way by training a new shoot or cane from the roots.

### Recurved-fan System

1. Save two strong canes on each side of the vine near the lower wire.

2. Cut them two and one-half to three feet long.

3. Leave a short spur for each cane as directed in pruning to the Kniffin System.

4. If no cane is available for a certain position use spurs to provide fruiting wood.

5, 6, 7, and 8. Follow directions given under Kniffin System.

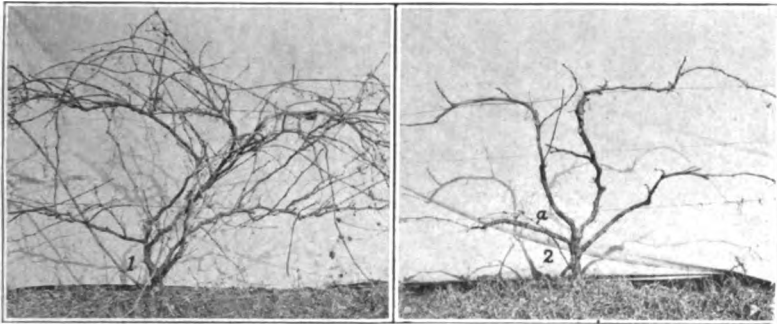


Plate XI.—A mature grapevine before and after pruning. The vine was originally headed for training to the fan system, but the early training was not followed up. Entirely too much wood was left at the present pruning. The only salvation is to train the cane at *a* in Fig. 2 into a new trunk.

### REJUVENATING OLD VINES

A vineyard in which pruning has been neglected soon becomes a liability rather than an asset. Neglected vines can rarely be restored to vigor and heavy bearing. In attempting to reclaim such a vineyard it is best to prune back heavily, making the saving of fruiting wood a secondary consideration in order to force a heavy growth of new wood from the trunk or main arms close to the trunk and from the roots. For this purpose canes arising close to the trunk should be “spurred” for wood production. The next season vines which have made sufficient new growth to permit remodeling may be saved but where only a weak growth has been made a cane growing from the root should be saved and the old top cut away.

Such treatment must be accompanied by thoro cultivation and fertilization of the soil.

### PRUNING AND TRAINING MUSCADINE GRAPES

Muscadine grapes differ from bunch grapes both in manner of growth and in fruiting habits, and require different methods of pruning and training.

Two systems of training give good results: (1) The canopy or overhead system, where the growth is trained as an overhead canopy seven to eight feet above the ground, or in a three-wire horizontal trellis; and (2) the six-arm Kniffin system, where the growth is trained to a three-wire upright trellis.

The upright Kniffin system is favored by most growers. It is

cheaper; the vines fruit earlier and are more easily pruned; and the vineyard can be cultivated more easily.

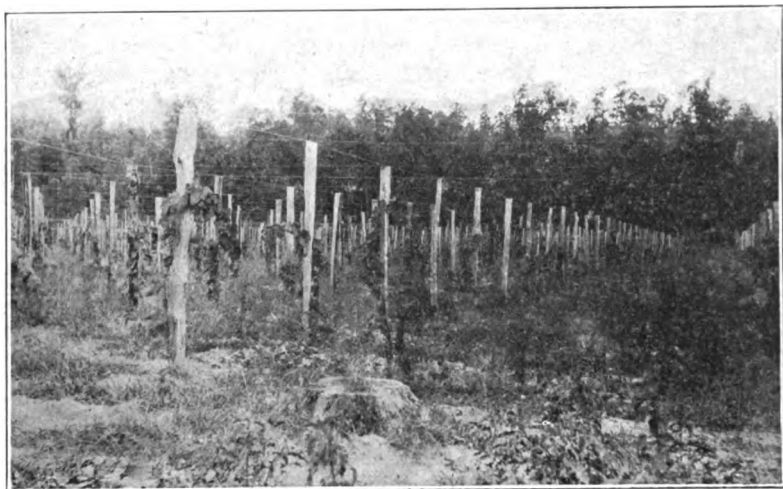


Plate XII.—Illustrates the overhead, or Canopy, trellis used for Muscadine grapes. Bunch grapes are also grown on such trellises but usually give inferior results when so trained.

Where the Kniffin system of training is followed the method of procedure, with young vines, is very similar to the training of bunch grapes, except that the trunk may be formed a year earlier.

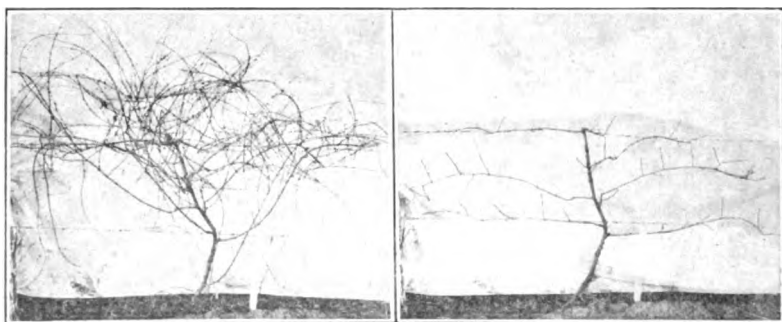


Plate XIII.—A Muscadine grapevine before and after pruning, trained to the six-arm Kniffin system.

Pruning of bearing vines consists of renewing the bearing

wood and keeping the vine healthy and vigorous. More fruiting wood must be left than on bunch grapes, and it is not necessary to renew the wood back to the trunk so frequently. A fruiting arm is developed along each wire on each side of the trunk. These arms may be maintained for a number of years. The canes arising from these arms are spurred back for fruiting wood. When it becomes necessary to renew an arm a new shoot is chosen from on, or close to, the trunk and the old arm cut away. It is best to renew only one or not more than two arms each year.

### SUMMER PRUNING

It is common practice to summer prune grapes in many localities in the United States. This consists of pinching off the tip of the growing shoot and it temporarily stops the growth of the vine in length. Within a week or ten days after pinching, lateral shoots appear and terminal growth is continued from a side bud near the end of the pinched shoot. A second pinching is usually again followed by new terminal growth in the same way but the greatest influence of the second pinching is to increase the vigor of the laterals. Many growers go thru the vineyard and pinch back these vigorously growing laterals. Another form of summer pruning consists in cutting off several inches of the growing shoots later in the summer.

The effect of summer pruning is to retard the lengthening of the shoots and to induce a more sturdy upright growth, which affords a better shade for the fruit. It tends to retard the more vigorous shoots and encourage the weaker ones and in some cases to force into growth buds which would otherwise remain dormant. The object of summer pruning is, of course, to increase the crop, but there are few experimental data to support the belief that fruitfulness is increased. In some instances a light, judicious pruning has given good results but the indications are that general heavy summer pruning is detrimental to the vines.

It is generally agreed, however, that vigorous, rapidly growing vines usually produce a number of superfluous shoots that should be removed during the growing season. There are also shoots which arise from weak buds or from buds on the arms and trunk of the vine. These are useless in most instances and where not needed for renewal purposes should be removed. The pinching, or heading back, of a vine in the summer to produce fruitfulness is a questionable operation except for the purpose of keeping vigorous, rapidly growing varieties within bounds. The removal of any great amount of foliage weakens the vine to a certain extent and the resultant production of laterals thickens the vine too much, shades the fruit too heavily, and delays the maturing of the wood. At present the best growers summer prune only as

the season, variety or other factors make it necessary to keep the plants within bounds and to remove superfluous wood rather than to increase the fruitfulness of the plant. Summer pruning is less harmful to young plants than to old and it is often found advisable to summer prune young plants as an aid in training.

### CULTIVATION

It is almost needless to say that clean culture is desirable thruout the season when the plants are producing fruit. Thoro and frequent cultivation should be given during the early part of the season. It is not sufficient merely to keep down weeds. The chief purpose of cultivation is to conserve moisture by checking evaporation; to keep down undesirable growth; and to put the soil in good physical condition. Cultivation will always be an important factor in the control of both insects and diseases. Turning the soil breaks up pupae cases of insects and exposes them to the weather and to birds. It also covers leaves and mummied fruits infected with diseases and thus prevents the scattering of spores. On most soils it is usually necessary and always desirable to begin operations in the spring by turning the soil with a plow. The soil of a single middle should all be turned the same way. About ten days later it should be plowed in the opposite direction. From this time on cultivation may be given with any of a number of implements such as a disc, spring tooth harrow, corn cultivator, or any tool which will work the soil properly. The first two plowings will have ridged the soil up along the rows. These ridges should be leveled by using a grape hoe to throw the soil away from the row, soon after the grapes bloom. This will assist in controlling the grape root-worms. Cultivation should continue at frequent intervals up to within a few weeks before the grapes reach full size and begin to color, or about five to six weeks before harvest begins.

### COVER CROPS

Where barnyard manure is not available it is necessary to keep up the physical condition of Arkansas soils by plowing under manuring crops, and since our soil is more often lacking in nitrogen than other elements of fertility the crop should be one which supplies a large portion of this element. One of the best crops for this purpose is cowpeas. The pea seed may be sown broadcast and covered at the last cultivation of the season or may be drilled in five or six weeks before the fruit is to be harvested. The peas will be a few inches high at harvest time but little injury will result since peas at this age will bear a considerable amount of tramping and hard usage. Hairy vetch is also a desirable crop for supplying nitrogen but it is much more difficult to secure a stand of vetch than of cowpeas. Vetch should

be sown in the latter part of August or during September and plowed under the following spring. Rye is a very desirable winter crop, especially for rolling lands or lands which wash badly.

On soils of southern exposure and rocky, gravely surfaces which reflect the sunshine, sun scald of the fruit may become serious. In such cases a shade crop should be planted early enough in the season to shade the ground by the time the fruit is mature. Either cowpeas or soy beans are well adapted to this purpose. It should be remembered that lands which are too steep or rocky to cultivate are not desirable for vineyard purposes.

### FERTILIZERS

Fertilizers required by grapes on light soil do not differ widely from those required by other crops. Analyses and tests show that Arkansas soils are uniformly low in nitrogen and organic matter but that phosphoric acid and potash are usually present in larger quantities. Where the land has been cropped for some time, however, these elements may also be deficient. Fertilizer is best applied in the form of stable manure where it is available. In the absence of an adequate supply of barnyard manure it becomes necessary to depend upon commercial fertilizers and cover crops. What the requirements of a vineyard are can best be ascertained by experiment. The grower should determine his fertilizer needs by applying the different elements, nitrogen, phosphorus, and potassium alone and in combinations, to small blocks of his vineyard. By noting the kinds and amounts of fertilizers which give him the best results he will be better able to tell what his vineyard needs. Before deciding, however, that the need of fertilizer is the limiting factor, he should be sure that his cultural methods are correct, that insects and disease are under control, and that the vineyard is not suffering from improper drainage or for some other reason. Good results cannot be had from the application of fertilizers on poorly drained soils or in vineyards which suffer from winter injury or where insects and diseases are not under control. It should be remembered that Arkansas soils are more or less uneven that the fertilizers which will give good results in one vineyard may be useless in another.

The element which will be more often found deficient is nitrogen. On some of our light sandy or gravely soils both potash and phosphorus are often lacking. When it is determined that other conditions are favorable for growth and the trouble must be due to lack of fertility, the first element which should be supplied is nitrogen and after that phosphorus and potassium in the order named. Where it is available, the remedy would be to apply



barnyard manure at the rate of about ten or twenty tons per acre and work it into the soil thoroly. Where barnyard manure is used 100 to 500 pounds nitrate of soda in combination with the manure, at least during the first session, will often be found profitable since manure is usually low in quickly available nitrogen. Where the general fertility is low and manure is not available a complete 8-3-3 or 8-4-4 fertilizer, at the rate of 400 to 600 pounds per acre, should be tried. On account of the readiness with which nitrate of soda is lost from the soil by leaching, a part of the nitrogen should be in a more slowly available form, such as tankage or cotton seed meal. A good 8-4-4 fertilizer may be mixed at home by using the following formula:

|                                                                 |      |        |
|-----------------------------------------------------------------|------|--------|
| Acid phosphate (16 per cent)-----                               | 836  | pounds |
| Cotton Seed Meal (7 per cent)-----                              | 620  | pounds |
| Nitrate of Soda (15 per cent)-----                              | 127  | pounds |
| Manure Salt (22 per cent)-----                                  | 302  | pounds |
| Filler (sand, dry pulverized earth<br>or ground limestone)----- | 115  | pounds |
| Total-----                                                      | 2000 | pounds |

Sulphate of potassium may be used instead of manure salt. This latter material contains about 50 instead of 22 per cent potash and only about 133 lbs. for each ton of fertilizer will be needed. This will require the addition of 169 lbs. more filler to make a ton of 8-4-4 fertilizer.

### GRAPE PESTS

Grapes like other fruits are attacked by numerous pests, which in many instances do considerable damage. At present there is comparatively little damage to grapes, in Arkansas, from either insects or diseases. The Grape Leaf-hopper, the grape berry moth, the Flea Beetle and the Curculio are causing some annoyance and some loss occurs from infections of Black Rot, Anthracnose, and other minor diseases. These pests will become more troublesome and others will appear as the grape industry develops.

Growers should, when they discover insects or diseases with which they are not familiar, send specimens to the Experiment Station for identification and recommendations for control.

**Flea Beetle.** It is only recently that flea beetle has caused enough damage to attract attention. The insect is a small steel-blue beetle which eats into the buds just as they are ready to burst.

The control is spraying with a strong dosage of arsenate of lead, applied to the swelling buds.

**Curculio.** The adults appear about blossoming time and feed largely upon the tender growing foliage. Later the berries are injured during the process of egg depositing.

The control may be carried out by adding arsenate of lead to the Bordeaux used in the early spraying for black rot before and after blooming.

**Grape Berry Moth:** This is the insect which causes most of the wormy grapes in Arkansas vineyards. The worms feed on all kinds of grapes but are especially destructive to late varieties. The worms feed on the stems and flowers and eat their way into, and destroy the berries themselves. Damage results from the direct loss of fruit which necessitates the picking out of worthless berries and from the marring of the clusters.

This pest is rather difficult to combat, but thoro spraying affords practically complete control. Arsenate of lead at the rate of  $1\frac{1}{2}$  lbs. to 50 gals. of standard Bordeaux mixture, to which is added  $1\frac{1}{2}$  to 2 lbs. of resin-fish-oil soap should be applied just after blooming or soon after the fruit is set. Another application is advisable about three weeks later.

**Grape Leaf Hopper:** The grape leaf hopper is already doing considerable damage in some vineyards. The injury varies with the season and locality. Vineyards located near favorable hibernating places usually suffer most. The insects damage the leaf by puncturing the skin and sucking out the sap. The winter is passed under fallen leaves and dead grass or similar protection. The insects emerge from their hiding place in early spring, feed on blackberries, raspberries, etc., and migrate to the grapes as soon as the leaves appear, where eggs are laid from which the early brood hatches. The young hoppers are wingless but they later develop wings and reach the adult stage by mid-summer when eggs are laid from which a second brood develops.

To control leaf hoppers; first, avoid planting raspberries, blackberries, etc., near the vineyard; second, spray with a contact insecticide while the insects are still young; and third, destroy hibernating places. To be effective the spray must come in contact with the insects before they develop wings. The best spray for this purpose consists of 40% nicotine sulphate at the rate of  $\frac{1}{2}$  lb. to 100 gals. of water or Bordeaux mixture. It must be applied on both the lower and the upper sides of the leaves in order to reach all of the insects. All weeds, tall grass, and trash near the vineyard should be destroyed.

**Black Rot:** Black rot is the most destructive fungous disease of grapes in this section. Infection arises early in the spring from mummied grapes, dead tendrills, and canes, and spreads from these sources to the leaves, stems and fruit. The principal

damage is to the fruit which turns black and shrivels. When the infection is light only a few berries in each cluster may be damaged, but this ruins the sale of the fruit unless the affected berries are removed, and the removal of such berries is a laborious and expensive task.

Since the disease is carried through the winter on mummied fruits and on diseased wood the first step in its control is the destruction of these sources of infection. All dead parts of the vines should be removed at pruning and thoro cultivation given early in the spring to turn under mummied fruit and diseased leaves. Pruning and training of the plants to admit plenty of air and to keep the vines off the ground goes a long way in the control of this disease. This treatment, together with spraying with standard 4-4-50 Bordeaux mixture will afford complete control. The first spray should be made just before the vines blossom and the second soon after the fruit sets. In some instances a third and even a fourth spray will be necessary at intervals of about two weeks. It is sometimes necessary, in cases of heavy infection, to spray just before the fruit begins to ripen.

**Anthracoze:** Grape anthracnose, or bird's-eye-rot, is a serious grape pest in some localities, and may become so here, where varieties other than Conocord are planted. Fortunately this variety is not very susceptible to anthracnose. All green parts of the vine are subject to infection throughout the growing season, but it occurs most commonly on the shoots and berries. Control measure consists of first, pruning out and burning all diseased wood; second, in spraying the vines while dormant with lime sulphur at the rate of one part to eight or nine parts of water, or with double or triple strength Bordeaux; and third, summer spraying with standard Bordeaux as recommended for black rot.

### GENERAL CONTROL MEASURES

There are many other pests which do more or less damage in neglected vineyards, but they are usually controlled incidentally where good cultural and spraying methods are followed. It is not usually necessary to apply separate treatments for each individual insect or disease, though in extreme cases it may become advisable to employ a specific remedy for some certain pest until it can be controlled by ordinary means. It is always the best policy to watch closely and begin the campaign against such invaders before any considerable damage is done. It is much easier to keep a pest out of a vineyard than it is to control it after it once gets a foothold.

**Vineyard Sanitation:** Thoro cultivation will go a long way toward keeping the vineyard free from pests. A good system

is to plow deep, preferably with a turning plow, early in the spring. Follow with shallow level cultivation. Level the ridges along the rows with a grape hoe soon after the grapes bloom. Plow again in the fall and sow a winter cover crop, such as rye, which will remain green all winter. This need not interfere with a cover crop of cowpeas earlier in the year for enriching the soil. Keep weeds and trash out of the vineyard and avoid slovenly pruning. Remove all dead or diseased portions of the vine and haul them out of the vineyard. Destroy the hibernating places of insects by cleaning up fence rows and "briar patches" near the vineyard. Do not plant cane fruits near the vineyard.

### SPRAYING

It is not necessary to spray for each insect or disease separately. Arsenate of lead for controlling chewing insects, nicotine sulphate for controlling leaf hoppers and aphids, and Bordeaux mixture for controlling disease, may all be mixed together and applied at the same time, thus making one application serve for all, provided it can be put on at the proper time for each.

Where only one spray is given for general protection number two in the regular schedule should be employed. If it is desired to make one application do for controlling leaf hopper also, the third regular spray including nicotine sulphate will be more satisfactory. If Black Rot becomes very destructive all of the regular sprays may be necessary.

Many of our growers keep their vineyards in such a good state of sanitation that the need of spraying is often reduced. Our best growers, however, feel confident that they are repaid for at least one thoro spraying with Bordeaux and arsenate of lead, no matter if few pests are present.

### MATERIALS

**Bordeaux Mixture** is the only fungicide which will ordinarily be needed for grape spraying.

Standard 4-4-50 Bordeaux mixture should be used except where otherwise specified. By 4-4-50 we mean four pounds of copper sulphate, or blue stone, and four pounds of stone lime (weighed before being slaked) to each fifty gallons of total mixture.

To prepare Bordeaux mixture dissolve the blue stone in hot water or put it in a clean sack and suspend it in a barrel of water so that the crystals are just covered. For convenience in mixing, the barrel should contain one-half gal. of water for each pound of bluestone.

Slake the lime in the regular way and then add water until the total amount used will equal one-half gal. for every pound.

Mix by putting the desired amount of bluestone solution into the spray tank, (two gallons for every fifty gallons of spray mixture to be made) start the engine and begin filling the tank. Take the required amount of lime and add water until it is reduced to a thin paste. When the spray tank is two-thirds full pour the lime through the screen into the tank. Reduce the required amount of Arsenate of lead to a thin paste by mixing with water, and pour through the screen in the same way. Keep the agitator going since the lead does not dissolve and must be kept in suspension by stirring. Bordeaux mixture should be made only as needed, as it will keep for only a short time.

The stock solution of copper sulphate can be kept for an indefinite period of time if the water is not allowed to evaporate.

A convenient stock solution of copper sulphate can be had by keeping more crystals in the container than the water will dissolve. By doing this each gallon of the saturated solution will always contain about fifty ounces or three pounds of copper sulphate to the gallon, regardless of how much evaporation takes place. By using these figures the amount of stock solution required to make any amount of spray can be easily determined.

Lime may be held in stock solution by keeping it covered with water. In order to know how much to use in mixing, a definite amount of water should be used in slaking.

**Hydrated lime** makes a very satisfactory Bordeaux mixture. It will be necessary to use one-third more lime when using the hydrated material. No slaking is necessary when hydrated lime is used. All that is necessary is to reduce it to a thin paste by mixing with water and put it in the spray tank.

**Nicotine:** Tobacco or nicotine sprays may be made at home or the commercial product may be used. The latter is usually more satisfactory in that it is standardized, and in a very convenient form for use. The home made product is prepared by steeping, not boiling, one pound of tobacco stems or cheap tobacco for one hour in water and diluting to two gallons. The prepared product, nicotine sulphate, (40%) is usually used at the strength of  $\frac{1}{2}$  lb. to 100 gals. of water or Bordeaux mixture. Two pounds of scap added to each 50 gals. should be used to facilitate spreading and covering.

**Dry Arsenate of Lead:** This is the most satisfactory poison to use for all biting or chewing insects, such as the grape root-worm and the grape berry-moth. It is usually used at a strength of 1 to  $1\frac{1}{2}$  lbs. to 50 gals. of spray. Arsenate of lead does not dissolve but must be kept in suspension by stirring. Therefore it is necessary to keep the spray material well agitated as it is applied, in order to insure an even distribution of poison over the parts to be protected.

## SPRAY CALENDAR

| Application           | What to Spray for                                                                 | When to Spray                                           | What to Spray With                                                                                                                      |
|-----------------------|-----------------------------------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| Dormant               | Scale<br>Anthracnose                                                              | In the spring<br>before buds be-<br>gin to swell.       | Lime-Sulfur solution,<br>1 gal. to 7 gal. of wa-<br>ter for both Scale and<br>Anthracnose, or Bor-<br>deaux, 8-8-50 for<br>Anthracnose. |
| Special<br>Bud Spray. | Flea Beetle<br>only.                                                              | As buds are<br>swelling. Re-<br>peat in 5 to 7<br>days. | 3 lbs. dry Arsenate of<br>lead to 50 gal. of<br>water.                                                                                  |
| 1st Regular<br>Spray. | Black Rot<br>Anthracnose<br>Curculio<br>Flea Beetle                               | Before Blos-<br>soms open.                              | 1½ lbs. dry Arsenate<br>of lead and Bordeaux<br>4-4-50.<br>2 lbs. of Resin-fish-oil<br>soap.                                            |
| 2nd Regular<br>Spray. | Black Rot<br>Anthracnose<br>Curculio<br>Berry Moth                                | After Bloom-<br>ing                                     | Same as for preceding<br>application.                                                                                                   |
| 3rd Regular<br>Spray. | Black Rot<br>Anthracnose<br>Leaf Hoppers<br>Berry Moth<br>and other in-<br>sects. | About 2 weeks<br>after No. 2                            | Same as for preced-<br>ing application, with<br>4 oz. Nicotine Sulfate<br>(40%) to each 50 gal.<br>if Leaf Hoppers are<br>present.      |
| 4th Regular<br>Spray. | Black Rot<br>Anthracnose<br>Insects                                               | About 2 weeks<br>after No. 3                            | Same as for<br>1st Regular Spray.                                                                                                       |
| 5th Regular<br>Spray. | Black Rot<br>Insects                                                              | About 2 weeks<br>after No. 4                            | Same as for<br>1st Regular Spray.                                                                                                       |

## SPRAYING EQUIPMENT

The equipment necessary for spraying grapes will depend upon the size of the vineyard. Where grapes are grown in connection with other fruit crops, the planting should be so arranged that the same spray machine may be used for all; but

where no other fruit crops are grown, an outfit especially designed for grape spraying may be used to advantage. On small acreages a barrel sprayer will be found most economical, especially where only one or two sprayings are given.

Regular orchard sprayers can not be used conveniently in vineyards where the rows are closer than nine feet. Where the width of rows will permit of their use orchard sprayers are very satisfactory indeed. Men may follow behind the rig and operate the nozzles, or the nozzles may be placed on booms attached to the rear end of the rig. When booms are used the sprayer may be driven between two rows, and the side of each row next to the machine sprayed as the outfit moves along. On machines of large capacity booms may be built for spraying both sides of two rows at once.

When the nozzles are operated by hand, one or two men, following behind the sprayer, can do the work effectively. Where machines of large capacity are used, three men can work to good advantage by having a hose support rigged to the back end of the machine, so that one lead of hose may be used directly behind the machine and another in the middle on either side.

For controlling black rot or where leaf hoppers and Berry noths become abundant, hand spraying is preferred. The young hoppers will be found almost altogether on the under side of the leaves and the spray material must be directed from below. For this purpose the nozzles should be attached at an angle to short rods. The poles used in regular orchard spraying are unsatisfactory for vineyard work.

### HARVESTING

Altho grapes may be left on the vines for some time after they are ripe, the time for harvesting is comparatively short and every thing possible should be done in advance to make things run smoothly after harvesting is once begun.

**Equipment:** A packing shed will be necessary tho it need by no means be elaborate. For small acreages about all that is needed is a shelter or open shed for empty packages, filled containers as they come from the field, and packed fruit, with a small space for tables and for the packers to work. Large acreages will require more equipment. Some facilities for short-time storage of large quantities of fruit may become necessary. In localities where strawberries or apples are grown the same packing shed may be made to answer for grapes as well. Picking trays, baskets, shears, pickers, and facilities for getting the fruit to the packing shed should all be arranged for ahead of time.

The kind of picking receptacles used will depend upon how the fruit is to be disposed of. Where the fruit is sold in seven or eight pound climax baskets many growers pick directly into the

baskets. Others pick in wide, shallow trays, in which the fruit is hauled to the packing shed on wagons with special beds. Where the fruit goes to juice factories it is usually picked into special containers, furnished by the company, and not handled again until it reaches the factory.

**When to Pick:** It is often difficult for the beginner to determine just when grapes are ready to pick. Nearly all varieties color before they are ripe. Grapes, unlike other fruits, will not ripen up and improve in sugar content after they are picked and must remain on the vine until the desired quality is attained. There is always more or less temptation to pick too soon, with



**Plate XIV.**—Picking crate and stool used in harvesting grapes for the juice factory.



the result that grapes of such poor quality are marketed that the demand for future shipments is destroyed.

As an indication of the proper degree of maturity there is no better test than eating berries chosen at random from the vines. The color of the stem is also indicative. The stems of the clusters will turn brown and shrivel slightly before they are ripe enough to pick. In well ripened fruit the juice becomes slightly thick and sticky, and the seeds become dark brown and do not adhere to the pulp.

**Method of Picking:** Fruit should never be pulled from the vine. Such methods injure both fruit and vine. The picker should take hold of the cluster by the stem and cut the stem with a pair of shears and lay the cluster in the tray or basket. The berries themselves should be touched or handled just as little as possible. Handling makes a great deal of difference in the appearance of the fruit, especially in the case of black grapes with heavy bloom. Such grapes will show every spot where they have been touched with either hands or shears.

Grapes should never be picked when they are wet. Dampness encourages decay, besides spoiling the appearance of the fruit. Picked fruit should never be allowed to stand in the sun.

As the baskets or trays are filled they should be placed on the ground under the vines until they can be hauled in. For this purpose a wagon with springs is imperative. Special racks may be built for hauling several tiers of baskets or trays at one load.

**Grading:** Grapes are easily graded since usually only two grades are made, firsts and culls. Firsts must have the following qualities: The bunches must be of uniform size, and full, that is, there must be few or no berries missing from the stems; the grapes must be fully ripe and uniformly colored; and the fruit

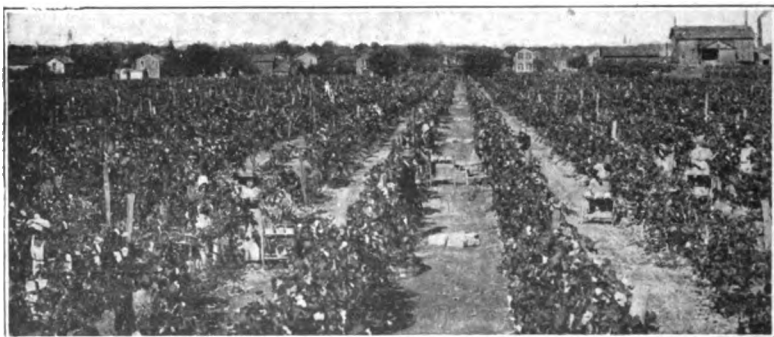


Plate XV.—Harvesting grapes and packing them into seven pound baskets in the vineyard.

must be free from either insect or fungous injuries. All grapes which fall below these specifications are culls. Only the fruit from good vineyards is worth grading.

Where grading is necessary it is advisable to have a shed where the fruit can be properly handled. A pair of slender shears is very satisfactory for removing diseased or crushed berries.



Plate XVI.—Hauling grapes from the vineyard. Rows must be wide enough to accommodate a standard tread wagon or special, narrow wagons must be built.

## MARKETING

There are now numerous channels through which grapes may be marketed. The consumption of grapes in the fresh state, while much smaller than it should be, is rapidly increasing. The market for table grapes can be greatly enlarged with profit to all concerned. An excellent opportunity is afforded Arkansas growers for developing a separate industry by growing and selecting high-class varieties that mature in succession throughout the season. The early fruit would meet with practically no competition, while our standard varieties reach the markets ahead of fruit from districts offering heavy competition. In the development of a market for table grapes, the smaller trade centers of our own state should not be overlooked.

Large quantities of grapes can be disposed of for grape juice, jams, and jellies. The juice industry alone will absorb a large share of all we can produce for some years. Grapes will not, as a rule, command as high prices for juice as for the table trade and consequently must be grown and handled more cheaply. Two and one-half to three tons per acre is a good average crop. The gross income per acre has been, under average Pre-war conditions, about \$95 to \$114. During the past few seasons the price has been \$125 to \$150 when sold to juice factories, though last season in New York the price reached a much higher level. The price of containers and the extra expense of harvesting and packing table grapes will amount to about \$35 an acre over the cost of marketing to juice factories. The price of table grapes is usually enough more, however, to encourage the production of large quantities for distant markets.

### ACKNOWLEDGMENT

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GIFT  
MAY 21 1921

UNIVERSITY OF ARKANSAS

COLLEGE OF AGRICULTURE

**Agricultural Experiment Station**

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**SEPTORIA GLUME BLOTCH  
OF WHEAT**

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**BULLETIN NO. 175  
(Technical)**

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**FAYETTEVILLE, ARKANSAS**

**MAY, 1921**

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# SEPTORIA GLUME BLOTCH OF WHEAT

H. R. ROSEN

ASSOCIATE PLANT PATHOLOGIST

## Introduction

A very marked spotting of glumes and rachis of a large number of wheat varieties has been under observation in Arkansas. For three successive seasons the wheat around Fayetteville has been severely attacked and due to the rush of work no attention was given to it until recently. Indeed, the only work done thus far by the writer has been to identify and compare this with other glume spotting heretofore described and to attempt some preliminary infection experiments. It may perhaps be desirable to call attention to this disease at this time since it is said to be serious in Europe and since the records of its occurrence in America are confined to a few notes which, very briefly, call attention to a *Septoria* associated with a glume spot. Besides being almost unknown in this country, no infection experiments have been attempted either here or abroad and proof of the pathogenicity of the organism is based entirely upon circumstantial evidence, namely, that of association with diseased spots.

## Symptoms

The most conspicuous symptoms are to be observed on the glumes, particularly the outer glumes. (See fig. 1.) The attacked parts are noticeably discolored, the discoloration appearing as brownish or purplish-brown spots or blotches, often with a hoary appearance, or brownish with a grayish-white center. The spots vary in size from 2 to 10 mm. or more, and no definite shape is ordinarily discernible. The upper parts of the glumes, which include the beards in bearded varieties, are the parts most likely to be attacked, although discolored spots are also to be observed on any part of the head, including the rachis. Upon the rachises, the discolored areas are found at or near the joints, occasionally extending over the entire internode, but in any case with no sharp boundary. When attacked nodes are cut into the discoloration may be noted in the interior tissues although not as pronounced as on the exterior; likewise, the interior surface of the attacked glumes is not as conspicuously discolored as the exterior. As compared to the black chaff disease, common at times around Fayetteville, the attacked parts are not as sharply delineated, usually lighter brown in color, and with no tendency to form streaks



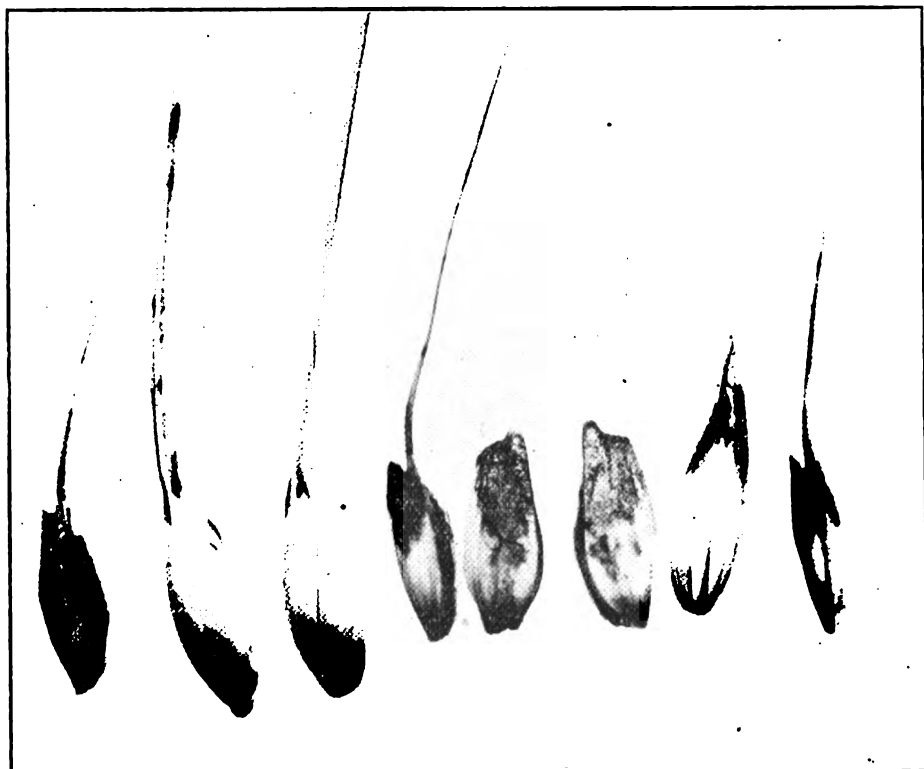


Fig. 1. Glume blotch on Kan Red (bearded) and Red May varieties. (Slightly enlarged.)

or stripes, one of the characteristic symptoms of black chaff. Compared to "scab" of wheat, rather rare in Arkansas, (Atanasoff (1) was unable to find any in this state), the attacked parts are considerably more discolored, there is little or no discoloration of heads attacked by *Fusarium*-blight, according to the same author, and the attacks in *Septoria* blotch are always more or less localized. The term "blotch" is used in preference to "spot" because of the irregular and indefinite nature of the discoloration.

Besides attacks on the heads, Frank (10 and 11) records leaf-blades as also attacked by the same fungus. The present writer has noted spots on leaves, frequently on parts of the sheaths at or near the nodes, which closely resemble the spots on the glumes; the peculiar greyish-white, hoary appearance on a purplish-brown background so characteristic of glume spots has also been noted on the leaf sheaths, and blades, and very often at nodes.

Moreover, the same fungus has been observed in leaf spots as in glume spots.

### Previous Records of the Disease

#### European Accounts

In 1845 Berkeley (3) described *Septoria nodorum* as producing spots on nodes of wheat in England. His description, as given by Grove (12), reads as follows, "Spots pale fawn-coloured, with a dark border, depressed, at length confluent; pycnidia slightly prominent; spores oblong, very slightly curved or irregular, containing a row of guttules. Makes its appearance at first under the form of little discoloured depressed spots on the nodes of the stem, especially the upper ones." Somewhat later Passerini described what appears as the same disease, according to Grove (l. c.), on the glumes of wheat in Italy. He also considered the pathogen a species of *Septoria*, giving it the name *S. glumarum*.

Since the spores of this pathogen vary considerably, even at maturity, it is not surprising that other writers should have overlooked the possibility of considering it a species of *Septoria* and have assigned it to other genera. Thus Kuehn (14) in 1877, paying no attention to Berkeley's work, described a new species of *Phoma* parasitic on wheat heads, especially the glumes. His description of the disease, translated, reads as follows:\* "It attacks particularly the upper half of the outer and inner glumes, also attacking at times down to the base of the outer glumes. The attacked parts take mostly a dirty grayish-violet appearance, which gradually become whitish-grey, the seat of the punctiform pycnidia." "By early and copious infections *Phoma Hennebergii* causes a reduced development, and in very unfavorable conditions even complete impoverishment of the seed, besides lessening in considerable degree the fodder value of the chaff."

In 1890 Ericksson (9) found the same disease near Stockholm. Forty acres of summer wheat were so heavily attacked that the whole field appeared red in the distance and a sound head was difficult to find. The kernels were off-color, shrunken and useless. On nearly every inner and outer glume one or more large, irregular, chocolate-brown spots were noted.

\* "Er tritt vorzugsweise an der oberen Haelfte der Klappen und Spelzen auf, geht bei erstern aber auch zuweilen bis an die Basis herab. Die befallenen Theile nehmen meist ein schmutzig grauviollettes Ansehen an, das an den Stellen allmaechlig in Weissgrau ausbleicht, wo die punktfoermigen Peritheecien hervorkommen.—Bei fruehzeitigem und haeufigem Auftreten verlanst *Phoma Hennebergii* eine minder vollkommene Ausbildung, in sehr ungunstigen Faellen selbst voellige Verkuemmung des Samens, benachtheiligt auch in erheblichem Grade den Futterwerth der Spreu."

Frank (11, p. 398 and p. 419) observed the disease in various localities in northern Germany. Attacked heads showing spotted glumes were found to be more or less numerous. Concerning the attack on leaves, he says, "Since 1894 I have found the fungus attacking the leaves as well as the glumes of wheat."

Various other European authors, including Sorauer, Tubeuf, Massee, and others, mention this disease but confine themselves to Kuehn's original description and add but little or nothing to the first accounts. The most recent references found by the writer are by Diedicke (7 p. 193 and p. 468) 1912 and 1914, and by Grove (12) 1916. These accounts are primarily devoted to the fungus.

From these descriptions, particularly those of Kuehn's and Eriksson's, it will be noted that the parts of the plant attacked and the nature of the attack correspond to that observed in Arkansas. The writer, through the kindness of Dr. W. A. Murrill of the New York Botanical Garden, and also through Dr. E. A. Burt of the St. Louis Botanical Garden\* has been enabled to examine some of Kuehn's original material (Rabenhorst, *Fungi europaei* No. 2261) and comparing it with Arkansas material finds them very similar both macroscopically and microscopically. (See fig. 2.) Besides the symptoms, the fungus found associated with the diseased parts in both Europe and America is similar and evidently the same species.

#### American Accounts

In contrast to the rather numerous European references, the disease thus far has hardly attracted attention in America. The first accounts appeared in 1898, one by Townsend (17 p. 126) from Maryland, and the other by Selby (16 p. 42) from Ohio. Townsend's account reads as follows:

"During the past season the wheat crop in certain sections of our State has been greatly injured by - - - a species of *Septoria* (probably *Septoria glumarum* [sic]). It does not appear that this fungus has heretofore produced any damage to wheat in this State, although it has been seen in Europe and possibly in some parts of our own country. I have not been able, however, to find any account of its appearance in America. It is seen soon after the heads are formed, and attacks the straw, leaves and glumes, but does not attack the grain itself. It spreads rapidly over the individual plants, and from plant to plant, and draws so much nourishment from its host just at the time when the heads are filling, that the kernels are very much shrivelled. It often appears most distinctly upon the heads, giving

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\* The writer gratefully acknowledges the help of Dr. J. A. Elliott in examining and securing material from Dr. Burt, and in looking up certain references.

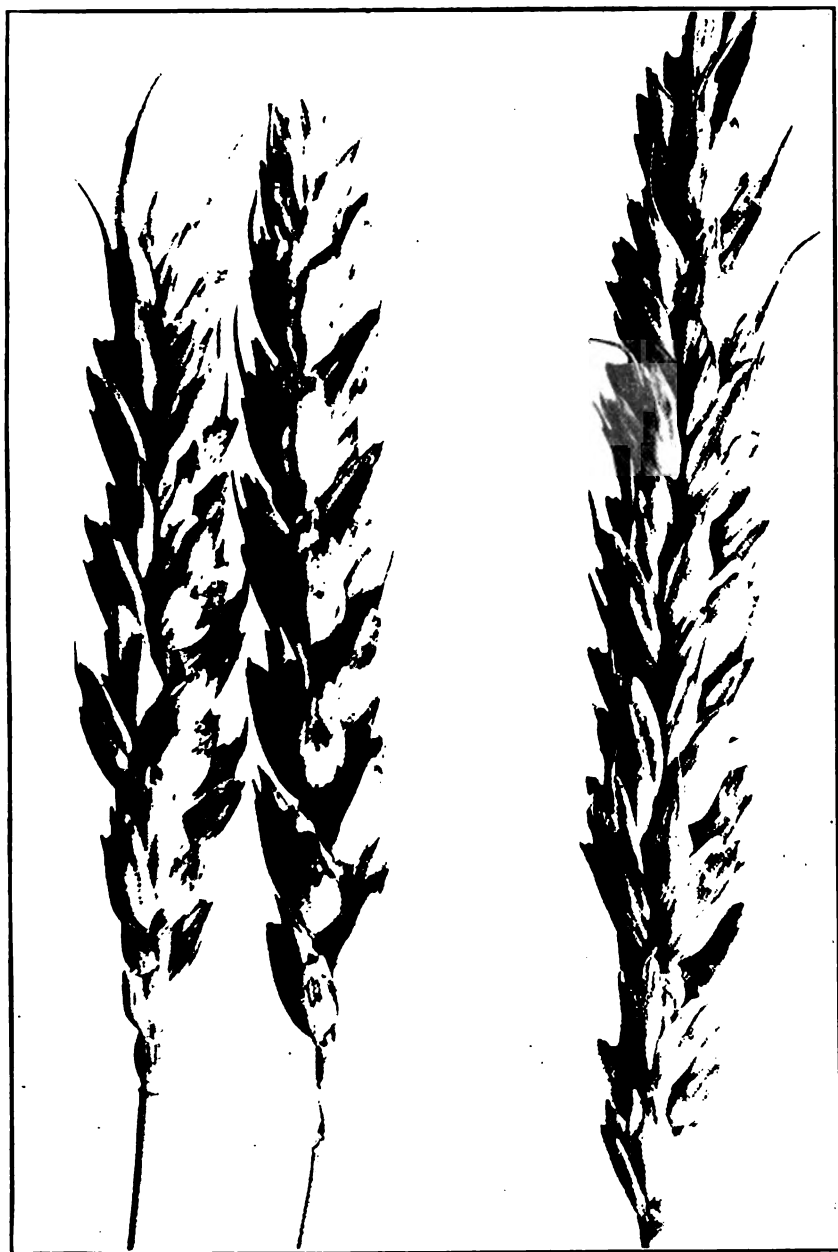


**Fig. 2.** Two heads at left showing glume blotch, Arkansas material. Head at right showing glume blotch, European material, (*Phoma Hennebergii*—Rabenhorst, *Fungi europaei* No. 2261)

them a dirty appearance. Upon close examination the infected parts are seen to be covered with numerous small, black dots which are masses of spores in little cavities (Pycnidia). It is impossible to estimate at this time, the amount of damage done by this fungus during the past season, but in a single instance, one field that gave every indication of producing from 30-35 bushels per acre of A. No. 1 wheat was so injured in a few days by this pest that the yield was reduced to 15 bushels per acre of inferior grain. In other sections the degree of injury has been more or less marked. It has been impossible to investigate the disease fully during the past season. If it appears next year it will receive special attention, the results of which will be published in another bulletin.

"It is probable that the suggestions given for the prevention of rusts (use of early maturing varieties and rotation) will in a measure prevent the destructive action of this disease."

This account leaves little doubt that the same disease as found in Arkansas is considered, although descriptions of the fungus, particularly of the spores, are missing and the possibility of attacks by *Septoria graminum* Desm. on the leaves must not be overlooked. Under the heading "Glume spot" Selby gives the following account, "The glumes of certain varieties grown by the Experiment Station, are frequently spotted by a pycnidial fungus. These dark spots are very conspicuous upon Velvet Chaff, the sort used as a standard in variety comparisons. Other varieties are more or less marked in the same manner. The fungus, in this case, appears to be one of the form genera and has been referred to *Septoria*." This brief description is hardly sufficient to place the disease definitely, but the reference to glume spots without leaf infections would make it appear that the disease producer is the same as the one under consideration. (*Septoria graminum* and *S. Tritici* are not known to attack glumes.) Davis' (6 p. 685) note of *Septoria glumarum* on dead, rusted leaves of wheat collected at Athelstane, Wisconsin may refer to the same fungus but since nothing is said of association with diseased or discolored spots it is not certain whether he treats of the disease which is here being discussed.

The only other American reference which may be considered to deal with the same disease is a recent note by Clinton\* (4 p. 481). His description reads, "Glume Blotch, *Septoria* sp. We collected this fungus once or twice in our disease survey work in 1918 as a very inconspicuous parasite on the glumes and leaves of wheat."

Two other American references should be noted, although it is very doubtful if the same disease is treated. Attention is

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\* The writer is indebted to Miss Edith K. Cash of the U. S. Department of Agriculture for this and other references.

called to a "*Septoria* blight of wheat - - - among those of special importance" in the State of Washington (18 p. 21), and Peck's account (15 p. 58) of *Macrophoma suspecta* (new species) as occurring on large leaf areas of dead basal leaves of winter wheat, in Kentucky.

### The Pathogen

Berkeley's original description of the disease as well as the associated fungus has already been cited. The account of the pathogen is very brief, no spore measurements are given, and it is due to Grove's (12) study of Berkeley's original material which makes it possible to identify *Septoria nodorum* with the disease under discussion. Grove has studied *Septorias* of wheat found in England and West Australia and as a result of these studies he concluded that *S. glumarum* Pass. was the same as *S. nodorum* Berk. He presents the following description:

"Pycnidia on the dead parts of the leaves, but without any distinct spots, very numerous, epiphyllous scattered all over the leaf, but arranged in short lines, somewhat crowded, 70-100 mic. in diameter, honey-coloured with a reddish tinge, then black, immersed, just perforating the epidermis with the minute pierced ostiole; texture very thin and soft, sinuately prosenchymatous, pellucid, ochraceous-brown, thicker and darker just around the ostiole, where the cells are distinct and parenchymatous. Spores oblong-fusoid or oblong-cylindrical, straight or angularly bent, or slightly curved or flexuous, obtuse at the ends or slightly pointed below, plainly 3-septate when mature, often with one or two guttules in each cell, sometimes faintly constricted at the septa, or more strongly at the middle one, about 15-16 mic. long when 1-septate, 20-26 by  $2\frac{1}{2}$ - $3\frac{1}{2}$  mic. when mature, singly colourless, but very abundant and long remaining clustered together in masses which generally showed a faint pinkish-isabeline tinge.

"As for the pycnidia on the glumes, the only difference was that they were larger, more erumpent, and prominent; the spores were identical. On the nodes the spores were the same, except that in the Cheshire specimens they were slightly narrower ( $2$ - $2\frac{1}{2}$  mic.) and in those from West Australia many were quite  $3\frac{1}{2}$  mic. wide. They were either non-septate or had one, two, or three septa, with frequently one or two minute highly refringent oil-guttules at each end, and on each side of the septa. The nodes show the pycnidia best after the leaves have withered; then the node shrinks and falls on, being fully invaded by the mycelium, which of course, stops the flow of sap and kills the host. The part of the node occupied by the pycnidia assumes a more reddish tinge, and the pycnidia become more prominent. There cannot be the slightest doubt that all three forms belong to the same species, occurring on the leaves, the nodes, and the glumes as the host plant advances in age."

Grove's description fits Arkansas material very well.

Kuehn (14) described *Phoma Hennebergii* as the cause of the

spotting of glumes and beards of summer wheat in Germany. His description of the fungus is as follows:\* "Perithecia (pycnidia) sparse, covered at first, finally with a round aperture, vertex mostly concave, about 0.1 mm. in diameter, dark, interior whitish; stylospores cylindrical, straight or slightly curved, 14.3-17.2 mic. long, 2.3 mic. wide, hyaline." In comparing this with other fungi found on the same host he states that it differs from *Phoma (Darluc) Filum* Cast. in the form of the spores, from *Phoma graminicola* Fuck. in the size of the spores and from *Septoria Tritici* in both shape and size, the *Septoria* having much longer and much narrower spores than *Phoma Hennebergii*. Concerning the spores he makes these additional remarks. Upon maturity they take the form of cirri (slightly curved or straight, thread-like bodies) and germinate immediately. They swell upon germinating presenting a wavy appearance because of the formation of one or more faint wrinkles; partitions do not appear. The germ tubes develop most frequently at the ends of the spores, although they may also appear at the sides. Near the spores there are found occasionally peculiar bladder-like extensions.

Kuehn's description, as a whole, is applicable to the Arkansas material. The following exceptions and additions are noted. The pycnidia are quite often numerous, particularly on the outer glumes, but owing to their size and origin they are readily overlooked, even with a hand lens. They are of subepidermal origin and vary considerably in size, the average being from 75 to 100 mic. When seen from above they appear globoid, cinnamon-brown in color with a round or oval ostiole at the apex, which measures 4-12 mic. in diameter; surrounding the ostiole the hyphae assume a much darker shade than the hyphae of the remainder of the fruiting-body. The spores even at maturity vary considerably in size, shape and in partitions. The average spores in Kuehn's material measure 15-18 by 2.8-3.0 mic., with occasional spores which are somewhat longer. Arkansas material at maturity, judged by the power to germinate, usually shows spores that are longer than the average spores of the European material, although pycnidia are readily found whose spores are no larger than the European spores. The average measure 18-25 by 2.8-3.0 mic.; spores measuring up to 30 mic. are not uncommon. In shape, the European as well as the American material agree, the average being cylindric with rounded apices and usually truncate or narrowed bases, and often slightly curved, although straight spores are common.

Kuehn's idea that no partitions are present is at variance with Eriksson's findings and with those of the writer. Kuehn's

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\* Peritheciis sparcis, primotectis, deinde apertis rotundatis, vertice plerumque concavis, circ. 0.1 M. M. diam. atris, nucleis albis; stylosporibus cylindraceis, rectis vel leviter curvatis, 14.3-17.2 Mik. long. 2.3 Mik. crass. hyalinis.

own material shows spores in which one cross wall in the equatorial region is common. Indeed, spores with two or three cross walls are not difficult to find, and that these are true partitions and not merely wall markings is made obvious by the shape which the spores assume upon germination. The spores as a whole swell or extend outward when germinating, except at the places where cross walls are noted, and at these loci the spores do not swell but appear constricted, thus giving them a wavy appearance. Kuehn noted this feature and there appears to be little doubt that the "Einschnuerungen" refer to constrictions brought about by the presence of cross-walls. Mature, viable spores often show slight indentations at the cross-wall even while they are not germinating. Apparently, the presence or absence of cross walls is not always associated with degree of maturity, if maturity is gauged by the ability to germinate. (One-celled spores have been observed to germinate as readily as two- or more-celled spores.)

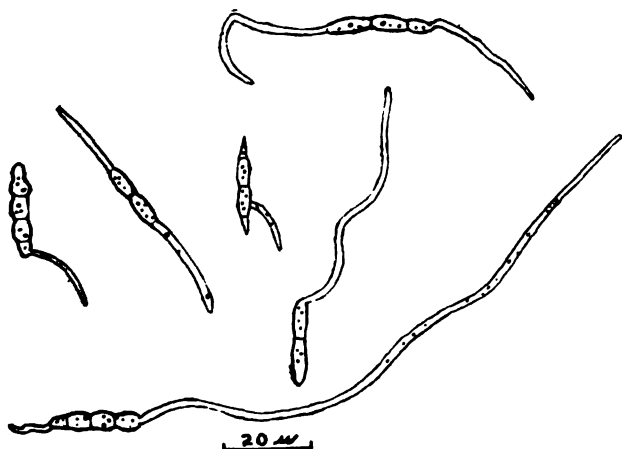


Fig. 3. Germinating spores of *Septoria nodorum*. (Material overwintered in the laboratory.)

The writer's observations upon the germination process agree well with Kuehn's. (See fig. 3.) The spores usually germinate from one or both ends, and sometimes from the sides. Material collected in the early summer and kept in the laboratory until the following May, germinated very readily, as much as 95 percent in some material. Pycnidia macerated in a drop of water and kept in a moist chamber overnight show numerous germinating spores the following morning. The germ tubes are hyaline, delicate, 2-4 mic. thick, and rapidly growing, sizes up to 150 mic. in length in 24 hours germination being not uncommon. At first, branching and septation are rare, but within 48 hours numerous, short, side-branches and frequent cross-walls appear.



### Genetic Relationship of the Parasite

It has already been noted that Kuehn described the fungus which he found in the glume-spots as a species of *Phoma*, namely *P. Hennebergii* nov. spec. No one, as far as the writer knows, has as yet questioned the validity of this species, all mycologists who have noted it, including Saccardo, accept this as a good species. The genus, however, in which this was first placed has been questioned and there is reason for still questioning any decision that may be made in this direction. In erecting the genus *Macrophoma*, Berlese and Voglino included *Phoma Hennebergii* as one of the species, since the ostiole is not markedly papillate, the pore is small, and since the spores measure more than 15 mic. Mention has already been made of the fact that Eriksson describes and figures the spores as being uniseptate, and that the writer finds the spores extremely variable with regards to partitions, uniseptate spores being very frequently found along with spores showing no septations or as many as three.

The matter of septation in the Fungi Imperfecti is extremely important from a taxonomic view point, and as far as most fungi in this group are concerned this is probably a good diagnostic character. As far as the fungus here described is concerned, the genus *Phoma*, *Macrophoma*, *Phyllosticta*, *Ascochyta*, *Stagonospora* as well as *Septoria* might be used with equal validity. It perhaps would be preferable to consider this fungus in the genus *Ascochyta*, since many, if not most, of the spores are uniseptate, and since the scoliosporous nature of the spores is not very evident, when compared with ordinary *Septorias*, such as *S. graminum*, *S. Tritici*, *S. Lycopersici*, *S. petroselini*, etc. Indeed, it did not occur to the writer that the fungus under discussion might be considered a *Septoria* until Dr. J. J. Davis identified the material sent to him, as *S. glumarum* Pass. Attention might also be called to the fact that numerous European mycologists and pathologists including Saccardo, Sorauer, Frank, Diedicke and others described *Phoma* (*Macrophoma*) *Hennebergii* and *Septoria nodorum* (*S. glumarum*) as two different fungi. Even Grove who has gone over the species of *Phoma* listed by Saccardo and who pointed out the similarity between *Septoria glumarum* and *S. nodorum* does not show this relationship.

The possibility that other species of *Septoria* described on the Gramineae may be the same as *S. nodorum* should not be overlooked. Diedicke (7) lists twenty species of *Septoria* on the Gramineae, most of which have the long, narrow spores of the *S. graminum* and *S. Tritici* type. There is one form, however, described as *S. fusispora* Died. new species (p. 467) on *Triticum* (*Agropyron*) *repens* whose spores measure the same as *S. nodorum*. The necessity of culturing these fungi and attempting artificial infections

before assigning relationships is as evident in this group as in other groups of fungi.

That the fungus under discussion is different from *S. graminum* and *S. Tritici* there can be little doubt. The latter fungi, which have been considered as the same species by some mycologists, are known to be present in this country and often do considerable damage in cool weather during the spring of the year, around Fayetteville. The writer has studied this Septoria, (for convenience it may here be considered as one species, *S. graminum*), and has carefully compared it with the one which attacks the glumes as well as the leaves, and invariably finds *S. graminum* possessing very long, narrow spores, (40-60 by 2.5 mic. is the measurement of the average spores), while the glume spotting fungus always has much shorter spores, 18-25 mic. being an average. The recent observations by Johnson (13), Beach (2), and Cromwell (5) on Septoria of barley and of wheat, speak only of leaf and seedling infections, no reference is made to any glume spotting. Johnson refers the fungus on barley to *S. graminum*, Beach refers to *S. Tritici* and Cromwell does not give any name. It appears that while *S. graminum*, or related forms, confines itself to leaf attack, *S. nodorum* may attack almost any part of the plant above ground. Artificial infection experiments seem to confirm this view. It is interesting to note the difference in temperature relationship. *S. graminum* attacks mostly during cool weather, while *S. nodorum* is primarily a warm weather pathogen, attacking the plants when they have made considerable growth, doing most of its damage after the plants have produced heads.

There are fungi going under other names than those already discussed which may be the same as *S. nodorum*. Durrell (8) describes an *Ascochyta*, probably *A. graminicola* Sacc., on dead wheat straw. He describes pycnidia as filled with guttulate spores which are usually two-celled and approximately 12-20 by 3.5-4 mic. His measurements would indicate a fungus whose spores are wider than spores of *Septoria nodorum*, but the possibility that the same fungus is involved should not be overlooked.

Davis (6) describes *Ascochyta graminicola* on *Calamagrostis canadensis* and the writer finds, on comparing the glume-spotting fungus with material kindly furnished by Dr. Davis, that the *Ascochyta* spores of his material are usually shorter and differ markedly in shape; they are fusiform and noticeably acute at both ends, while the other spores are cylindric, usually rounded above and truncate or narrowed below, never acute.

The fungi mentioned above are the only ones thus far found which deserve consideration. In this preliminary publication the writer is not attempting to give a complete and final list of synonyms or of morphological features. This, together with other

problems not yet solved remain for the future. A provisional technical description of the fungus follows:

*Septoria nodorum* Berk.

**Synonyms:**

*Septoria glumarum* Pass.

? *Septoria fusispora* Died.

*Phoma Hennebergii* Kuehn

*Macrophoma Hennebergii* (Kuehn) Berl. and Vogl.

? *Ascochyta graminicola* Sacc. in part.

Spots indefinite, often elliptical or elongated-elliptical, varying in color from a greyish-brown to dark-brown or purple-brown, often appearing light-grey on a purple background. Compared to Ridgway's color charts, Dresden brown, Saccardo's umber, bistre, and other colors may be included; occasionally a yellow indefinite halo appears around the brownish discoloration, but this is not as distinct as the halo usually found around brownish discolorations due to *Septoria graminum*. Pycnidia gregarious on spots of glumes, stems and leaves, inconspicuous, subepidermal, opening by a small oval or roundish pore, golden-brown at first, finally blackish, globoid, measuring 60-100 mic. in diameter. Spores cylindric, curved or straight, colorless, often adhering and issuing from the pycnidia in the form of serpentine threads, one to three septate, 18-25 mic. long by 2.8-3.0 mic. wide, rounded above and truncate or narrowed below, with or without guttulae.

**Artificial Infections**

Since no infection experiments have apparently been reported for this pathogen up to this time it may be worth while to present briefly the results of artificial infections. Wheat plants growing on a greenhouse bench were moistened by a water-spray and material containing spores was smeared on the moistened leaves and glumes. The spores in some experiments were obtained from pycnidia on material collected the previous summer and kept in the laboratory over winter, and in others were obtained from material of the current year. Inoculated plants were kept under large belljars, usually for three days, to prevent drying out, and where plants were too large to go under jars the inoculated parts were covered with large test tubes which were plugged with moistened cotton. Various leaf and glume infections were obtained (see fig. 4) with the production of pycnidia on the spots. The pycnidia bore spores which agreed in every respect with those observed in natural infections and it is interesting to note that spores coming from pycnidia born on glumes produced leaf infections and spores coming from leaves were able to infect glumes.

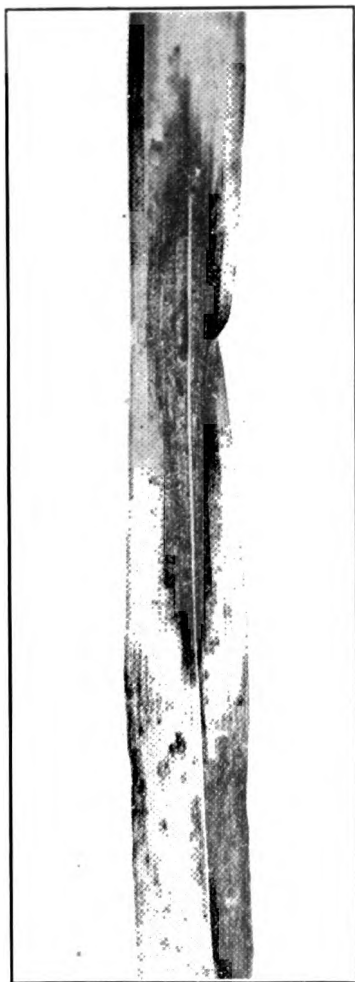


**Fig. 4.** Artificial leaf infections, brownish discolorations with yellowish halos. (Slightly enlarged.) Green parts of the leaf are not shown.

The symptoms induced by artificial infections were very similar to those of natural infections.

### Extent of Injury

Attention has already been called to the serious nature of the disease as reported from Germany and Sweden and to Townsend's report of severe damage in Maryland. The studies thus far concluded by the writer do not warrant any definite statement concerning the amount of damage. It is certain, however, that the disease is serious and according to observations made thus far it would stand next to leaf rust, (*Puccinia triticea*) which is the most serious disease of wheat in Arkansas, in amount of damage done. Leaf, stem, and head invasion all tend to weaken the plant, to produce undersized, shriveled kernels and to reduce the yield materially. Prof. L. W. Osborn in conversation with the writer, reports that the weight per bushel of wheat produced on the University farms during the last year has been lowered several pounds and he has associated this loss with marked discoloration of the heads.

A large number of wheat varieties have been attacked, among which are the standard winter wheat varieties, particularly the common red, winter wheats, including Red May, and Kan Red.

How widespread this disease is remains to be ascertained. It has been located in Independence County as well as in Washington County, two widely separated regions in this state and a careful survey would probably reveal its presence in other localities.

Experiments involving the possibility of controlling or eradicating this disease will be undertaken in the future. It appears that the use of early maturing varieties and proper crop rotation, practices which are ordinarily recommended for this region, should help in controlling this disease. The use of clean seed, preferably seed coming from farms which are known to be free from this disease, cannot be too strongly recommended.

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Gift  
DEC 27 1921

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COLLEGE OF AGRICULTURE

Agricultural Experiment Station

VITAMINS AND THE DAILY DIET

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# SPRAYING FOR SAN JOSE SCALE

W. J. BAERG

## INTRODUCTION

The purpose in taking up the project of Dormant Spraying was to determine the results that could be expected from the application of such insecticides as Dry Lime Sulfur, Soluble Sulfur, Barium Tetrasulfide, and "Scalecide." Since Commercial Concentrated Lime Sulfur solution has many times proved an effective insecticide, for the control of San Jose scale, it seemed well to use this as a standard for comparison.

The account of the work and observations presented in this bulletin is intended to be a preliminary paper. Although the work has been carried on for a period of three years; 1919, 1920, and 1921, yet in the light of recent observations on the heavy toll that San Jose scale has taken in orchards, apparently well sprayed, there doubtless remains something in regard to the control work that we need to learn.

The first two seasons the spray applications were made in the spring, just as the buds began to show green. In 1921 the applications were made when the buds were separating. As will be discussed later, the spring dormant spraying is known to be more effective than the fall, and the later the spring application the more effective it is.

The orchards used in this project were:—one five-acre orchard consisting of 6-8 year old trees, belonging to James Nichols, near Springdale; a small terrace orchard consisting of 4-year old trees belonging to the Experiment Station; and a three-acre variety orchard of 10-15 year old trees, on the new Experiment Station farm. In the Nichols orchard and the Terrace orchard the work and the observations cover a period of three years, and during all this time the same arrangement of plats was maintained, and the same materials were applied in the same way. The variety orchard has been sprayed but once, and the observations are for one season.

The arrangement of the plats and the materials used: The Nichols orchard, as is seen in fig. 1 was divided into four plats, one for each of the following materials:—Commercial Concentrated Lime Sulfur solution (made by the Kimmons-Walker Company, Springdale, Arkansas), at the rate of 1 gallon to 8 gallons of water; Scalecide\* (made by B. G. Pratt & Company, New York City,) at the rate of 1 gallon to 15 gallons of water; Barium Tetrasulfide (made by the General Chemical Company,

---

\*"Scalecide" is one of a number of well-known forms of miscible oil.

FIG. 1—NICHOLS ORCHARD

| W          |                  |             |         | N       |            |  |  |
|------------|------------------|-------------|---------|---------|------------|--|--|
| T T T      | T T T T          | T T T T     | T T T T | T T T T | T T T      |  |  |
| Soluble    | Barium Tetrasul- | "Scalecide" |         |         | Commercial |  |  |
| T T T      | T T T T          | T T T T     |         |         | T T T      |  |  |
| Sulfur, 14 | lb, 14 pounds to |             |         |         | al Lime    |  |  |
| (15)       | (14)             | 1:15        |         |         | (6)        |  |  |
| T fT T     | T T T T          | T T T T     |         |         | T fT T     |  |  |
| pounds to  | 50 gallons       |             |         |         | Sulfur     |  |  |
|            |                  |             |         |         | 1:8        |  |  |
| (16)       | (13)             | (7)         |         |         | (5)        |  |  |
| HT T T     | T T T T          | T fT T T    |         |         | T fT T     |  |  |
| 50 gallons |                  |             |         |         |            |  |  |
| T T T      | HT T T T         | T T T T     |         |         | T fT T     |  |  |
|            |                  |             |         |         | (4)        |  |  |
| T T T      | T T T T          | T T T T     |         |         | T T T      |  |  |
| (17)       | (12)             |             |         |         |            |  |  |
| fT T T     | T T T fT         | T T T T     |         |         | T T T      |  |  |
|            | (11)             | (8)         |         |         |            |  |  |
| T T T      | T T T T          | HT T T T    |         |         | T T T      |  |  |
| (18)       |                  |             |         |         |            |  |  |
| T T fT     | T T T T          | T T T T     |         |         | T T T      |  |  |
|            |                  | (9)         |         |         | (3)        |  |  |
| T T T      | T T T T          | fT T T T    |         |         | T HT T     |  |  |
|            |                  | (10)        |         |         |            |  |  |
| T T T      | T T T T          | T T fT T    |         |         | T T T      |  |  |
|            |                  |             |         |         | (2)        |  |  |
| T T T      | T T T T          | T T T T     |         |         | T CT CT    |  |  |
|            |                  |             |         |         | (1)        |  |  |
| T T T      | T T T T          | T T T T     |         |         | T CT CT    |  |  |
| E          |                  |             |         |         |            |  |  |

C—Checks.

H—Heavily infested, bark covered.

f. h.—Fairly heavy infestation.

f.—Fairly infested, scales easily found.

FIG. 2. TERRACE ORCHARD

W

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

Dry Lime Sulfur, 14 pounds to 50 gallons

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

---

T T T T T T T T

T T T T T T T T

"Scalecide", 1 gallon to

T T T T T T T T

15 gallons of water.

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

E

N

FIG. 3.—VARIETY ORCHARD

|   |                                                 | N                                               |                                |                     |   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|-------------------------------------------------|-------------------------------------------------|--------------------------------|---------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W | Dry Lime<br>Sulfur, 15<br>lbs. to 50<br>gallons | Dry Lime<br>Sulfur, 20<br>lbs. to 50<br>gallons | Lime Sulfur<br>Solution<br>1:8 | "Scalecide"<br>1:15 |   |   |   |   |   |   |   |   |   |   |   |   |   |
|   | T T T                                           | T T T                                           | T T T                          | T                   | T | T | T | T | T | T | T | T | T | T | T | T | T |
|   | T T T                                           | T T T                                           | T T T                          | T                   | T | T | T | T | T | T | T | T | T | T | T | T | T |
|   | T T T                                           | T T T                                           | T T T                          | T                   | T | T | T | T | T | T | T | T | T | T | T | T | T |
|   | T T T                                           | T T T                                           | T T T                          | T                   | T | T | T | T | T | T | T | T | T | T | T | T | T |
|   | T T T                                           | T T T                                           | T T T                          | T                   | T | T | T | T | T | T | T | T | T | T | T | T | T |
|   | T T T                                           | T T T                                           | T T T                          | T                   | T | T | T | T | T | T | T | T | T | T | T | T | T |
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|   | T T T                                           | T T T                                           | T T T                          | T                   | T | T | T | T | T | T | T | T | T | T | T | T | T |
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|   | T T T                                           | T T T                                           | T T T                          | T                   | T | T | T | T | T | T | T | T | T | T | T | T | T |
|   | T T T                                           | T T T                                           | T T T                          | T                   | T | T | T | T | T | T | T | T | T | T | T | T | T |
|   | T T T                                           | T T T                                           | T T T                          | T                   | T | T | T | T | T | T | T | T | T | T | T | T | T |
|   |                                                 | S                                               |                                |                     |   |   |   |   |   |   |   |   |   |   |   |   |   |

New York City), at the rate of 14 pounds to 50 gallons of water; and Soluble Sulfur (made by the Niagara Sprayer Company, Middleport, New York), at the rate of 14 pounds to 50 gallons of water. Four check trees were left in the southeast corner.

The Terrace orchard, see fig. 2, was divided into two plats, one for "Scalecide" and the other for Dry Lime Sulfur (made by the Shermin-Williams Company, Cleveland, Ohio).

The Variety orchard was divided into four plats, see fig. 3. Two for different strengths of dry lime sulfur, one for commercial lime sulfur solution, and the remainder for "Scalecide."

Spraying in the Nichols, and the Variety orchard was done with a Hardy Duplex Sprayer equipped with 10-foot poles, and four angle nozzles. In the Terrace orchard a Demming Barrel Sprayed was used. All the spraying was done through discs of 1/16 inch opening.

#### SEASON OF 1919

With a view of obtaining definite figures in regard to relative merit of the various insecticides, a count of live scale insects was made before and after treatment. For this purpose four trees that showed either a heavy or fair infestation of scale were selected in each plat, and from these and from two of the

four check trees, five pieces of twigs were removed for examination. These were terminal twigs about eighteen inches long and taken from various portions of the trees. The examination was made under a binocular microscope, and only the live scale insects were counted.

On twigs that were heavily infested, the insects were counted over a distance of one or two centimeters, and from the figures thus obtained the total was estimated.

The number of scale insects taken from the different trees, as is seen in the table below, varied between wide limits. This is mostly due to the fact that the twigs were taken at random from various parts of the tree, without any effort to get a certain degree of infestation. The examination was made on February 19.

The number of insects found on the trees labelled are as follows, five 18-inch twigs were taken from each tree:

|             |                     |              |                     |
|-------------|---------------------|--------------|---------------------|
| Tree No. 1. | 54 scale insects.   | Tree No. 10. | 316 scale insects.  |
| Tree No. 2. | 48 scale insects.   | Tree No. 11. | 10 scale insects.   |
| Tree No. 3. | 2452 scale insects  | Tree No. 12. | 258 scale insects.  |
| Tree No. 4. | 45 scale insects.   | Tree No. 13. | 994 scale insects.  |
| Tree No. 5. | 131 scale insects.  | Tree No. 14. | 111 scale insects.  |
| Tree No. 6. | 54 scale insects.   | Tree No. 15. | 477 scale insects.  |
| Tree No. 7. | 220 scale insects.  | Tree No. 16. | 864 scale insects.  |
| Tree No. 8. | 2883 scale insects. | Tree No. 17. | 285 scale insects.  |
| Tree No. 9. | 92 scale insects.   | Tree No. 18. | 2205 scale insects. |

The selection of the check trees was somewhat unfortunate. The infestation on these trees was rather slight, and this was later nearly destroyed by the lime sulfur that was carried over by a moderate wind.

The Nichols orchard was sprayed on March 14, using the following materials: (see fig. 1). Commercial Lime Sulfur solution; "Scalecide"; B. T. S.; and Soluble Sulfur. The Terrace orchard was sprayed on March 15, using "Scalecide," and Dry Lime Sulfur. (See fig. 2). Weather conditions were favorable. The maximum temperature for the two weeks following the spraying ranged between 57-76° F. The buds at the time of spraying were just beginning to show green.

**Results.** On April 14, a month after the spraying, twigs were again taken from the same trees and in the same manner as was done before the spraying. These twigs were examined in the same manner as described above. The results of the examination were as follows:

## Twigs from Mr. Nichols' Orchard,\*

Cut on April 14, 1919.

Examined on April 15, 1919.

| Material Used  | Tree No. | No. of Live Scales | Degree of Infestation Before Spraying. |
|----------------|----------|--------------------|----------------------------------------|
| Check          | 1        | 19                 | Light                                  |
|                | 2        | 15                 | Light                                  |
| Lime Sulfur    | 3        | 1                  | Very Heavy                             |
|                | 4        | 1                  | Light                                  |
|                | 5        | 1                  | Medium                                 |
|                | 6        | 0                  | Light                                  |
| Scalecide      | 7        | 0                  | Medium                                 |
|                | 8        | 1                  | Very Heavy                             |
|                | 9        | 2                  | Light                                  |
|                | 10       | 0                  | Medium                                 |
| B T S          | 11       | 2                  | Light                                  |
|                | 12       | 49                 | Medium                                 |
|                | 13       | 137                | Heavy                                  |
|                | 14       | 4                  | Medium                                 |
| Soluble Sulfur | 15       | 41                 | Medium                                 |
|                | 16       | 50                 | Heavy                                  |
|                | 17       | 12                 | Medium                                 |
|                | 18       | 40                 | Very Heavy                             |

\*See preceding table.

Checks do not afford as striking a contrast as would be desirable, as the twigs unfortunately had but few scales. Nearly all of those that had reached the proper stage of development, had wintered well, and were about full-grown. The males were about to emerge or had already done so.

The twigs of Lime Sulfur and "Scalecide" plats showed results very definitely, numerous scales in the right stage, and practically all dead.

Comparing these figures with those obtained in the first count, it is seen that the Commercial Lime Sulfur and the "Scalecide" showed fairly definite and good results. Barium Tetrasulfide, and soluble Sulfur were not as effective. Of these two the Soluble Sulfur seems to be slightly more effective. The check

trees were disappointing. The fatalities among the insects were apparently due to the lime sulfur that was carried over by a moderate south wind.

On November 11, 1919, the various plats were examined again, and live scale was found on many of the trees. At this time the twigs were selected with a view of getting the largest possible number of scale insects. Ten terminal twigs about 18-20 inches long were taken from five different trees in each plat. An examination of these twigs gave the following figures:

|                           |                          |
|---------------------------|--------------------------|
| Lime Sulfur Plat          | -106 live scale insects. |
| Scalecide Plat            | -100 live scale insects. |
| Barium Tetrasulfide Plate | -158 live scale insects. |
| Soluble Sulfur Plat       | -352 live scale insects. |

These figures do not indicate the relative merits of the various insecticide materials, for the reason that in the Lime Sulfur and the "Scalecide" plats it required considerable searching to find twigs with live scale insects. This was not necessary in the Barium Tetrasulfide and the Soluble Sulfur plats.

Comparing the Barium Tetrasulfide and the Soluble Sulfur at this time it is seen by the figures that the Barium Tetrasulfide has the advantage over the Soluble Sulfur. This was confirmed by a careful examination of the other trees in the two plats. The examination made April 14 seemed to show the opposite. The change came during the summer when it was observed that the young insects were establishing themselves much faster in the Soluble Sulfur plat than they were in the Barium Tetrasulfide plat.

The check trees showed a few live scale insects, but not enough to warrant the counting.

In the Terrace orchard, since the trees were small and thus easily examined, it was considered unnecessary to bring twigs into the laboratory. Accordingly a number of general examinations were made during the summer and fall which showed that "Scalecide" and Dry Lime Sulfur were about equally effective. A few live scale insects were found in the Dry Lime Sulfur plat, late in the fall. The object in using the "Scalecide" here was mainly, to determine whether or not it would injure the young trees when used each year for 3-4 years.\*

#### SEASON OF 1920

The Nichols and the Terrace orchards were sprayed on March 22 and 23 respectively, using the same materials and maintaining the same plats as in 1919. Weather conditions

\*Anderson—Ill. Hort. Soc. Rpt., 1920, p. 87-88.

Glenn—Ill. Cir. 180, p. 22.



were favorable. The maximum temperatures for the two weeks following the spraying ranged between 50 and 78° F. The buds had begun to swell and were showing green at the time of spraying. The check trees were abandoned, partly because the drifting lime sulfur in the previous season made them almost valueless, and partly because the owner fairly begged to have them sprayed. While this is contrary to usage in experimental work, yet considering that San Jose scale was very common and in several orchards had killed many trees, it was believed that the use of the check trees could be dispensed with.

### Results

The observations in regard to the results of the second year's work were made on November 13. At this time all the trees were carefully examined for live scale insects, but no material was taken to be examined under the microscope.

**Commercial Lime Sulfur.** In this plat a few, 5 or 6, trees were found with live scale insects. These infestations, however, were distinctly restricted to small regions in the tree. Obviously they originated from a few overwintering scales that were missed when we sprayed.

**"Scalecide."** The results in this plat were contrary to what was expected. Live scale insects could be found on practically every tree, and with but little difficulty. On some of the trees the infestation was becoming rather marked. What this striking difference in the results of the two seasons is due to is problematical. For the first season's work the material was sent directly from the headquarters of the manufacturer; this year the material was purchased from a local dealer.

**Barium Tetrasulfide.** The trees in this plat had nearly the same degree of infestation as was found in the "Scalecide" plat. Live scale insects could be found on many of the trees; but the infestation was nowhere as conspicuous. The infestation was markedly less than at the end of the previous season.

**Soluble Sulfur.** A number of the trees had scale insects. Since the trees in this plat are much smaller than those of the other three plats, the results cannot reasonably be ascribed to a failure in covering the entire tree with the spray material.

The results in this plat were very much like those in the Barium Tetrasulfide plat, although live scale insects could be found on many of the trees; yet it showed a decided decrease from the condition of last year.

**Terrace Orchard.** The observations here were made at various times during the summer and fall. Late in the fall a number of the trees in the Dry Lime Sulfur plat showed a slight infesta-

tion. The results in the "Scalecide" plat were markedly better, practically no live scale insects could be found. The "Scalecide" used here was taken from the supply of the previous year, which was shipped directly from headquarters of the manufacturers.

### SEASON OF 1921

This year the work was extended to cover the 3-acre Variety orchard in addition to the Nichols and Terrace orchards. These orchards were sprayed on March 8, 9, and 10 respectively. In the Nichols and the Terrace orchards the same plats were maintained and the same materials were applied as in the previous seasons. In the Nichols orchard a spray gun was used in the place of one of the rods. The gun was kept on the same hose all the time so that in case any infestations would appear they could properly be traced. Special care was taken with the gun, spraying the trees from all sides, and using a generous amount of material.

The Variety orchard was sprayed with Dry Lime Sulfur (two different strengths), Liquid Lime Sulfur solution, and "Scalecide." (See fig. 3.)

Weather conditions this year were more favorable than any other year. The maximum temperature for the two weeks following the spraying ranged between 48 and 84° F. On several days the temperature went to 80° or above.

### Results

On June 9 all the trees in the Nichols orchard were examined. In the Soluble Sulfur plat a large number of trees showed dead scale insects, but no live insects, either old or young, could be found. The Barium Tetrasulfide plat also showed dead scale insects on a few trees, no live scale could be found. In the "Scalecide" plat there were a few traces of scale, no live insects could be found. In the Commercial Lime Sulfur plat all traces of scale insects had disappeared.

On August 1 the trees in this orchard were again examined and the observations given above were confirmed, with the additional feature that many of the dead scales had dropped off. There could not be found any live scale insects.

On June 10 all the trees in the Terrace orchard were examined, dead scales were found on a number of trees, but no live scale insects were in evidence.

On August 2 the orchard was again examined and the observations given above were confirmed.

The Variety orchard was examined on June 11. Dead scales were fairly common, and could be found on nearly all the trees. There was no evidence of live scale insects, either old or young.

On August 2 the trees in this orchard were again examined

as before and the same results were obtained.

The results of this season are strikingly better on control work than those of the seasons of 1919 and 1920, in that all materials used appeared to be entirely effective. The high temperature at the time of spraying was probably responsible for this.

### DISCUSSION OF RESULTS

**Commercial Lime Sulfur Solution.** Judging from the results just discussed, covering three year's work, it appears that Lime Sulfur stands first in effectiveness among the materials that have been tested. Infested trees examined thirty days after spraying, gave definite results. Wherever the material had been applied all the insects were dead. There were no indefinite cases. This cannot be said of any of the other sulfur compounds.

Comparing Lime Sulfur with "Scalecide" the former is preferable because it spreads better, or putting it in another way, it wets up the tree quicker. "Scalecide" has a tendency to collect on the bark and then run down. My experience is that the use of "Scalecide" involves more care, in order to make a thoro application, and it likewise involves at least as much material. In so far as I know this is contrary to all published statements, excepting one made by Mr. Leroy Childs\* of the Oregon Experiment Station.

**"Scalecide."** According to the results of these experiments "Scalecide" would come second in efficiency, judging solely by the effect it had on San Jose scale. It has decided advantages over Lime Sulfur in that it has no very noticeable unpleasant effects on the human skin. It does not corrode the pumps and presents no difficulties in mixing. Its disadvantages compared with lime sulfur solution have already been discussed.

There is a claim made in advertisements that the application of "Scalecide" for a period of three years has a "stimulating" effect, so that the trees sprayed will be "in every way better" than the trees sprayed with lime sulfur. I can find no evidence for the claim in all the work that has been done. On the other hand there are certain publications\* which state that "Scalecide" when applied for 3-4 years in succession will injure, and in some instances kill the trees. I have been unable to find any evidence of injury caused by the use of "Scalecide," either in the Nichols orchard (trees 8-10 years old) or the Terrace orchard (trees 4-5 years old.) In both of these orchards "Scalecide" was used for three successive seasons.

**Barium Tetrasulfide.** This material would stand third in

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\*Oregon Hort. Rept. 1920, p 122.

\*Anderson, Ill. Hort. Soc. Rpt. 1920, p 94.

Glenn, Ill. Cir., 180, p 22.

efficiency for dormant spraying. In the work of 1919 and 1920 the material came in a coarse crystalline form. These crystals were rather slow in going into solution, hence much time was lost in making up the mixture. In 1921 the material was in the form of a dull black powder, which when sifted slowly into the tank, already filled, and the agitator going, dissolved quite readily. Whether this material will be more effective against the San Jose scale than was the crystalline form, remains to be shown.

As can be seen from the foregoing pages, the *combined* effect of the three season's spraying with this material is entirely satisfactory; but the results of the one or even two year's spraying are clearly below those of the Commercial Lime Sulfur solution, and of "Scalecide" also.

Attention has already been called to the fact that when trees that had been sprayed were examined a month later, there were many dead insects, but there were many that were indefinite. In other words, although the insects gave no clear evidence of being alive, yet they were plump and full of liquid, while the results in the "Scalecide" and the Liquid Lime Sulfur plats were clear and definite.

**Soluble Sulfur.** This material would come fourth in efficiency for the control of San Jose scale. An examination of the sprayed twigs gave practically the same results that are given for Barium Tetrasulfide. However, after a number of observations made at intervals of about a month, I have observed that Barium Tetrasulfide has an inhibiting effect on San Jose Scale, (i. e., prevents young scale from settling) which lasts decidedly longer than it does in Soluble Sulfur.

Soluble Sulfur apparently passes very rapidly into solution, and causes no trouble in nozzles.

**Dry Lime Sulfur.** Owing to the fact that this material was not at hand when the work on the Nichols orchard was begun, it was not included in that test. The test in the Terrace orchard and the Station orchard indicates that Dry Lime Sulfur is fairly effective in killing San Jose scale. However, since it was tried under different conditions than the former materials, given above, one cannot draw any definite conclusions as to where it would stand in regard to the other materials tried. However, apparently it is preferable to Barium Tetrasulfide and Soluble Sulfur, in so far as its efficiency as an insecticide is concerned.

**The Dry Materials.** B. T. S., Dry Lime Sulfur, and Soluble Sulfur, while highly effective in the season of 1921, were not so satisfactory during the two previous years, and cannot yet be given as strong a recommendation as Lime Sulfur. They have the advantage that they can be hauled more readily over rough roads.

There is no trouble with leaking containers. These materials are purchased in substantial tin containers in which they can be kept almost indefinitely; provided the cans are in a fairly dry place.

### CONTROLLING SAN JOSE SCALE

A considerable number of failures to control San Jose scale have been reported. As a rule the trouble was attributed to a poor quality of lime sulfur solution. Various attempts have been made to substantiate this claim, but in most cases these have failed.

It is well known that only such equipment as will make the most thorough work possible, that is, a sprayer equipped with rods and the type of nozzles that throw a fine mist, can be relied on in cases of severe infestation of scale. The spray gun, although it is still held very much in favor by many growers, has without a doubt given rise to a number of failures in dormant spraying. In my opinion the spray gun cannot be used successfully for this purpose unless the trees are small and the grower is willing to waste about half of his spray material. The spray gun will not wet the upper surface of the twigs, unless the spraying is done from above or the material is allowed to drop down on the twigs. This is will not do in the form of a fine mist. Furthermore, in a moderate wind, it is almost impossible to make a thoro application with a spray gun. By the use of angle nozzles on rods the spray can be directed at the twigs from all different angles so that no place remains uncovered.

Proper pruning obviously is essential for successful dormant spraying. Trees from 12-15 years old that have been allowed to grow in their own way for many years, and then develop a severe infestation of scale, cannot be sprayed with any degree of success. Such trees should be severely pruned so that the tops are well thinend out.

### THE SEASON FOR SPRAYING

It has long been known that spraying for scale in spring, just before the buds show green, is about twenty per cent more effective\* than spraying in the fall after the leaves have fallen. However, there are other features to be considered. Dormant spraying is relatively slow work. One ordinary power sprayer equipped with a 3-5 H. P. engine should not be expected to cover more than six acres of average-sized trees a day.

Furthermore, the weather is very uncertain during the time of spring dormant spraying. It is well to allow at least three days time for one day of spraying. And, in addition, in some

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\*Forbes, Ill. Bull. 180, p 555, 561.

years the development of the buds comes much earlier than in others, and proceeds at a very rapid rate. The season of 1921 is a good illustration of this. Many growers had only just started with the work when the buds began to separate. At this time all dormant spraying must be discontinued, or severe burning may be the result.

For these reasons, if the orchard is large and with a fair infestation of scale, and the spraying equipment limited, the grower will do better to apply at least a part of the dormant spray in the fall. Very heavily infested trees should be sprayed in the fall, and again in the spring.

If the orchard is small, involving only 2-3 days work, or the spraying equipment sufficient to make the entire application in a week or less time, then the spring application is to be preferred, provided, as already indicated, the trees are not heavily infested.

### DOSAGE OF LIME SULFUR

In the experiments recorded in this paper, Lime Sulfur solution was used at the rate of 1 gallon to 8 gallons of water. All the spraying was done in spring, and moreover, at the particular time (when the buds were beginning to swell) when spraying is most effective.

The United States Bureau of Entomology recommends for dormant spraying, 1 gallon of Lime Sulfur solution to 7 gallons of water\*. The recommendation is based on many years experimentation, and is doubtless intended for spraying to be effective in fall as well as in spring.

In the fall when the temperature is going down, when cold weather often sets in during the spraying, or soon after it, it will probably be necessary to use the dosage recommended by the United States Bureau of Entomology.

### SUMMARY

The results of the work in Dormant Spraying may be summed up as follows:

Lime Sulfur is the most effective of all the materials tested.

The others may be arranged, relative to efficiency and advantages, as follows:

"Scalecide," Dry Lime Sulfur, Barium Tetrasulfide, Soluble Sulfur.

Dormant Spraying, in order to be effective, must be done thoroly, every portion of the infested tree must be covered with the spray material.

The spring application of the dormant spray is the most

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\*Farmers' Bulletin 650.

effective. This must be finished before the buds begin to separate. If spraying is to be done in spring, ample time should be allowed for unfavorable weather and unexpected progress in the development of the buds.

### DESCRIPTION OF SAN JOSE SCALE

San Jose scale is a small oval-shaped insect, of a yellowish color. It lives underneath a black or grayish scale which consists partly of wax secreted by the insect and partly of the cast-off skins of the insect.

The following description of San Jose scale as it appears on the trees refers to the scales and not to the insects proper. These can be examined only under the microscope.

During the fall and winter, when the trees are dormant, the scales may be found on the bark of the trees. In a slight infestation the scales will appear as small, round, black and grayish spots. (See Plate I.) Many of them, especially on the last year's growth will be surrounded by reddish discoloration in the bark. When fully developed, they are about 1/16 of an inch in diameter, or the size of a pin head. The black spots represent half-grown scale insects, and are therefore smaller.

In the summer and fall the scales may be found not only on the bark, but also on the leaves and the fruit. In fact a rather light infestation may often be located best when the apple crop is nearly mature. The scale insects on the fruit cause a bright red discoloration before the remainder of the apple develops this color.

The accompanying plates represent a heavy infestation of San Jose scale, enlarged about eight times, and also as it would appear in natural size.

### PRICES OF THE VARIOUS MATERIALS

These quotations were received between August 15 and 23, 1921:

Liquid Lime Sulfur, 14 cents a gallon in barrel lots (or \$7.00 for a 50-gallon barrel).

"Scalecide," \$38.44 for a 50-gallon barrel.

Dry Lime Sulfur, \$25.00 for 200 pounds.

Barium Tetrasulfide, \$30.00 for 300 pounds.

Soluble Sulfur, \$12.00 for 100 pounds.

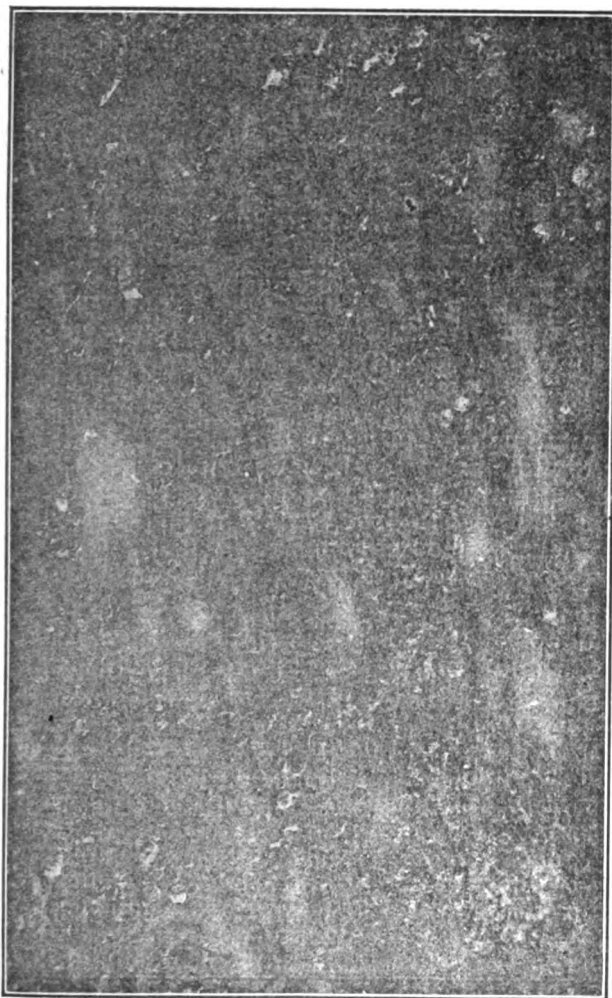


PLATE I

San Jose scale, enlarged about 8 times. Notice the small round bodies with white nipples in the center.



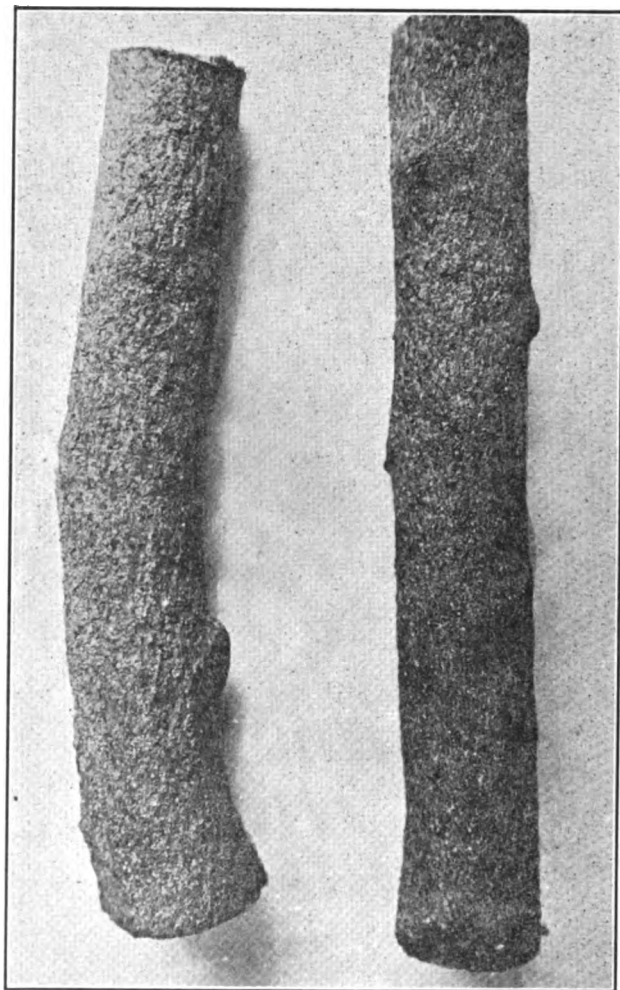


**PLATE II**

San Jose scale, about natural size. Notice the grayish-white appearance of the bark.

### ACKNOWLEDGMENT

I am much indebted to Doctor J. A. Elliott, Plant Pathologist of the Experiment Station, and Professor Dwight Isely, formerly of the United States Bureau of Entomology, now Associate Entomologist of this Experiment Station, for reading of the manuscript and many helpful suggestions and criticisms.



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## RESULTS OF FERTILIZER EXPERIMENTS

1919-1920-1921

MARTIN NELSON—WARD H. SACHS

The average yield of most farm crops produced in the state is far too low. These low yields are in a large measure due to the low fertility of the soil upon which the crops are produced. Farm manure is probably the best fertilizer that can be used, but farmers are realizing that there is not sufficient manure produced to maintain the fertility of the soil under cultivation. As a result they are turning to the use of commercial fertilizers.

The Agricultural Experiment Station has been carrying on tests with fertilizers for some time, the results of such tests up to the year 1917 having been reported in Bulletin No. 155, the supply of which is now exhausted. The tests with which this bulletin deals were conducted during the years 1919, 1920, and 1921. Similar work is being continued this present season. The tests, the larger portion of which have been carried out in co-operation with the county agents and some farmer which they have selected, have been located at rather widely distributed points throughout the state.

### SEASON 1919.

The early part of the season of 1919 was wet, and farmers were unable to work their land as well as they wished. As a result of the poor preparation of the seed bed the crops on the thinner lands of poor physical condition were greatly affected by short, dry period during the summer. The heavy rains in the fall made harvesting difficult and caused considerable injury, especially in the southern part of the state. The season as a whole was more favorable in the northeast section than in the southwest portion of the state.

The tests on the farms of Mr. Joe Boyd and Mr. J. W. Knott, near Lewisville, Lafayette County, were on sandy loam upland soil typical of that section of the state. The test on corn was on somewhat richer soil, but this soil was not as well drained as the soil on which the cotton test was placed. The largest increases in yield of seed cotton were produced by the heavier applications of complete fertilizer, the lighter application of complete fertilizer, and by the addition of manure. Several of the treatments more than doubled the yield of seed cotton. The response to the use of farm manure is clearly shown. The largest increases in yield of corn were produced by manure reinforced by acid phosphate, and by the two applications of complete fertilizer. The lighter application of complete fertilizer produced the largest increase per pound of material applied in the case of corn, as in the case of cotton.

## ARKANSAS EXPERIMENT STATION

## COSATAL PLAINS SOIL

| Plot No. | Treatment Per Acre                                             | SEED COTTON                           |                  | CORN                                     |                 |
|----------|----------------------------------------------------------------|---------------------------------------|------------------|------------------------------------------|-----------------|
|          |                                                                | John Winham<br>Joe Boyd<br>Lewisville |                  | John Winham<br>J. W. Knott<br>Lewisville |                 |
|          |                                                                | Yield Per<br>A Lbs.                   | Increase<br>lbs. | Yield Per<br>A. Bu.                      | Increase<br>Bu. |
| 1        | None -----                                                     | 210                                   | ---              | 13.0                                     | ---             |
| 2        | 100 lbs. 15% Nitrate of Soda-----                              | 340                                   | 130              | 14.5                                     | 0               |
| 3        | 250 lbs. 16% Acid Phosphate-----                               | 450                                   | 240              | 15.4                                     | -.6             |
| 4        | 30 lbs. 50% Potash-----                                        | 300                                   | 90               | 16.0                                     | -1.5            |
| 5        | None -----                                                     | 130*                                  | ---              | 18.9                                     | ---             |
| 6        | 10 Tons Well Rotted Manure-----                                | 570                                   | 370              | 23.1                                     | 3.4             |
| 7        | 250 lbs. 16% Acid Phosphate-----                               | 510                                   | 310              | 25.7                                     | 5.2             |
|          | 100 lbs. 15% Nitrate of Soda-----                              |                                       |                  |                                          |                 |
| 8        | 100 lbs. 15% Nitrate of Soda                                   | 320                                   | 120              | 23.9                                     | 2.6             |
|          | 30 lbs. 50% Potash-----                                        |                                       |                  |                                          |                 |
| 9        | None-----                                                      | 200                                   | ---              | 22.0                                     | ---             |
| 10       | 250 lbs. 16% Acid Phosphate                                    | 300                                   | 92               | 25.6                                     | 4.9             |
|          | 30 lbs. 50% Potash-----                                        |                                       |                  |                                          |                 |
| 11       | 100 lbs. 15% Nitrate of Soda                                   | 580                                   | 365              | 30.7                                     | 11.2            |
|          | 250 lbs. 16% Acid Phosphate-----                               |                                       |                  |                                          |                 |
|          | 30 lbs. 50% Potash                                             |                                       |                  |                                          |                 |
| 12       | 250 lbs. 16% Acid Phosphate<br>10 Tons Well Rotted Manure----- | 460                                   | 237              | 35.4                                     | 17.1            |
| 13       | None -----                                                     | 230                                   | ---              | 17.0                                     | ---             |
| 14       | 200 lbs. 15% Nitrate of Soda                                   | 660                                   | 437              | 32.6                                     | 16.6            |
|          | 500 lbs. 16% Acid Phosphate-----                               |                                       |                  |                                          |                 |
|          | 60 lbs. 50% Potash                                             |                                       |                  |                                          |                 |
| 15       | 100 lbs. 15% Nitrate of Soda<br>applied on 15 inch plants----- | 160                                   | -55              | 18.4                                     | 3.5             |
| 16       | 2000 lbs. Crushed Limestone-----                               | 210                                   | 2                | 19.3                                     | 5.4             |
| 17       | None -----                                                     | 200                                   | ---              | 12.9                                     | ---             |

\*Not used in calculations.

The test with cotton on the farm of Mr. Garland Choate, in Yell County, was located on Hanseville fine sandy loam, a commonly occurring type in this section of the state. The soil became thinner from No. 1 to No. 17, and the change was not altogether uniform. Manure and acid phosphate show the largest increases.

The soil on which the test with cotton on the farm of Herman Glick, Clebourne County, was located was a fine sandy loam, a typical type in this section of the state. The lighter application of complete fertilizer, manure reinforced by acid phosphate, and manure alone produced the largest increases.

# RESULTS OF FERTILIZER EXPERIMENTS

5

## HILL SOIL

| Plot No. | Treatment Per Acre           | SEED COTTON                             |              |                                             |              | CORN                                        |             |                                             |             | SORGHUM (SWEET)                         |              |
|----------|------------------------------|-----------------------------------------|--------------|---------------------------------------------|--------------|---------------------------------------------|-------------|---------------------------------------------|-------------|-----------------------------------------|--------------|
|          |                              | E. B. Randle<br>G. Choate<br>Dardanelle |              | S. Kennedy<br>Herman Glick<br>Heber Springs |              | E. B. Randle<br>A. G. Saddler<br>Belleville |             | S. Kennedy<br>Joe Phillips<br>Heber Springs |             | Best-Clymer<br>Mfg. Co.<br>S. Ft. Smith |              |
|          |                              | Yield<br>Per A.<br>Lbs.                 | Inc.<br>Lbs. | Yield<br>Per A.<br>Lbs.                     | Inc.<br>Lbs. | Yield<br>Per A.<br>Bu.                      | Inc.<br>Bu. | Yield<br>Per A.<br>Bu.                      | Inc.<br>Bu. | Yield<br>Per A.<br>Tons                 | Inc.<br>Tons |
| 1        | None                         | 920                                     | ---          | 950                                         | ---          | 12.1                                        | ---         | 27.4                                        | ---         | 3.05                                    | ---          |
| 2        | 100 lbs. 15% Nitrate of Soda | 880                                     | ---          | 840                                         | ---          | 12.4                                        | ---         | 30.7                                        | 2.3         | 3.80                                    | 59           |
| 3        | 250 lbs. 16% Acid Phosphate  | 970                                     | 145          | 890                                         | 95           | 13.2                                        | 1.7         | 33.0                                        | 6.6         | 5.65                                    | 2.27         |
| 4        | 30 lbs. 50% Potash           | 790                                     | 2            | 910                                         | 57           | 12.0                                        | 1.7         | 28.3                                        | 0.9         | 4.00                                    | .46          |
| 5        | None                         | 730                                     | ---          | 820                                         | ---          | 11.1                                        | ---         | 27.4                                        | ---         | 3.70                                    | ---          |
| 6        | 10 tons well rotted manure   | 800                                     | 143          | 1120                                        | 285          | 11.3                                        | .2          | 28.0                                        | 0.6         | 6.10                                    | 2.26         |
| 7        | 250 lbs. 16% Acid Phosphate  | 720                                     | 135          | 1090                                        | 200          | 12.7                                        | 1.7         | 29.3                                        | 1.9         | 6.90                                    | 2.92         |
| 8        | 100 lbs. 15% Nitrate of Soda | 570                                     | 58           | 1130                                        | 205          | 12.1                                        | 1.1         | 31.7                                        | 3.7         | 5.00                                    | .88          |
| 9        | 30 lbs. 50% Potash           | 440                                     | ---          | 860                                         | ---          | 10.9                                        | ---         | 27.4                                        | ---         | 4.25                                    | ---          |
| 10       | None                         | 540                                     | 103          | 1120                                        | 195          | 14.7                                        | 3.5         | 29.3                                        | 1.9         | 6.75                                    | 1.69         |
| 11       | 250 lbs. 16% Acid Phosphate  | 540                                     | 105          | 1210                                        | 320          | 15.7                                        | 4.2         | 30.1                                        | 2.7         | 6.05                                    | 2.17         |
| 12       | 250 lbs. 16% Acid Phosphate  | 340                                     | -92          | 1190                                        | 335          | 17.3                                        | 5.5         | 35.0                                        | 7.6         | 6.40                                    | 2.71         |
| 13       | 10 tons well rotted manure   | 430                                     | ---          | 820                                         | ---          | 12.1                                        | ---         | 27.4                                        | ---         | 3.50                                    | ---          |
| 14       | None                         | 430                                     | 23           | 1030                                        | 197          | 21.1                                        | 9.0         | 36.3                                        | 8.9         | 5.70                                    | 1.40         |
| 15       | 200 lbs. 15% Nitrate of Soda | 340                                     | -45          | 858                                         | 5            | 13.6                                        | 1.5         | 32.4                                        | 6.0         | 5.25                                    | .25          |
| 16       | 500 lbs. 16% Acid Phosphate  | 440                                     | 78           | 880                                         | 22           | 11.0                                        | -1.1        | 27.7                                        | 0.3         | 6.30                                    | .55          |
| 17       | 2000 lbs. Crushed Limestone  | 340                                     | ---          | 870                                         | ---          | 12.1                                        | ---         | 27.4                                        | ---         | 6.50                                    | ---          |
|          | None                         | 340                                     | ---          | 870                                         | ---          | 12.1                                        | ---         | 27.4                                        | ---         | 6.50                                    | ---          |



## ARKANSAS EXPERIMENT STATION

## DELTA SOIL

| Plot No. | Treatment Per Acre                                             | SEED COTTON                     |                       | CORN                            |                      |                                         |                      |
|----------|----------------------------------------------------------------|---------------------------------|-----------------------|---------------------------------|----------------------|-----------------------------------------|----------------------|
|          |                                                                | Burdette Plantation<br>Burdette |                       | Burdette Plantation<br>Burdette |                      | A. P. Reynolds<br>L. D. Atkins<br>Hazen |                      |
|          |                                                                | Yield<br>Per A.<br>Lbs.         | In-<br>crease<br>Lbs. | Yield<br>Per A.<br>Bu.          | In-<br>crease<br>Bu. | Yield<br>Per A.<br>Bu.                  | In-<br>crease<br>Bu. |
| 1        | None -----                                                     | 1490                            | ----                  | 51.5                            | ----                 | 20.7                                    | ----                 |
| 2        | 100 lbs. 15% Nitrate of Soda-----                              | 2080                            | 502                   | 50.3                            | .9                   | 19.7                                    | 0.5                  |
| 3        | 250 lbs. 16% Acid Phosphate-----                               | 2360                            | 695                   | 45.5                            | -1.7                 | 23.3                                    | 3.6                  |
| 4        | 30 lbs. 50% Potash-----                                        | 2920                            | 1167                  | 45.1                            | .1                   | 19.0                                    | -.2                  |
| 5        | None -----                                                     | 1840                            | ----                  | 42.0                            | ----                 | 18.7                                    | ----                 |
| 6        | 10 Tons Well Rotted Manure-----                                | 2100                            | 170                   | 40.7                            | -4.9                 | 18.9                                    | 2.1                  |
| 7        | 250 lbs. 16% Acid Phosphate                                    | 2270                            | 250                   | 47.9                            | -.4                  | 19.6                                    | 4.6                  |
|          | 100 lbs. 15% Nitrate of Soda-----                              |                                 |                       |                                 |                      |                                         |                      |
| 8        | 100 lbs. 15% Nitrate of Soda                                   | 2950                            | 640                   | 48.0                            | -3.0                 | 9.4                                     | -3.6                 |
|          | 30 lbs. 50% Potash-----                                        |                                 |                       |                                 |                      |                                         |                      |
| 9        | None -----                                                     | 2200                            | ----                  | 53.7                            | ----                 | 11.4                                    | ----                 |
| 10       | 250 lbs. 16% Acid Phosphate                                    | 2600                            | 410                   | 48.9                            | -4.9                 | 16.4                                    | 3.8                  |
|          | 30 lbs. 50% Potash-----                                        |                                 |                       |                                 |                      |                                         |                      |
| 11       | 100 lbs. 15% Nitrate of Soda                                   | 2890                            | 710                   | 49.7                            | -8.7                 | 19.9                                    | 6.1                  |
|          | 250 lbs. 16% Acid Phosphate-----                               |                                 |                       |                                 |                      |                                         |                      |
|          | 30 lbs. 50% Potash                                             |                                 |                       |                                 |                      |                                         |                      |
| 12       | 250 lbs. 16% Acid Phosphate<br>10 Tons Well Rotted Manure----- | 2600                            | 430                   | 44.7                            | -8.5                 | 23.4                                    | 8.4                  |
| 13       | None -----                                                     | 2160                            | ----                  | 53.1                            | ----                 | 16.1                                    | ----                 |
| 14       | 200 lbs. 15% Nitrate of Soda                                   | 2270                            | 60                    | 48.4                            | .9                   | 22.0                                    | 5.9                  |
|          | 500 lbs. 16% Acid Phosphate-----                               |                                 |                       |                                 |                      |                                         |                      |
|          | 60 lbs. 50% Potash                                             |                                 |                       |                                 |                      |                                         |                      |
| 15       | 100 lbs. 15% Nitrate of Soda<br>applied on 15 inch plants----- | 2839                            | 570                   | 58.0                            | 12.5                 | 8.3                                     | -7.8                 |
| 16       | 2000 lbs. Crushed Limestone-----                               | 2300                            | -10                   | 46.3                            | 4.6                  | 8.6                                     | -7.5                 |
| 17       | None -----                                                     | 2360                            | ----                  | 37.9                            | ----                 | ----                                    | ----                 |

The test with corn on the farm of Mr. A. G. Saddler, located on rather thin sandy loam upland in Yell County, gave largest increases where the heavy application of complete fertilizer, complete fertilizer and manure, and acid phosphate were used. These increases, however, did not pay for the fertilizer used.

The test with corn on the Jobe Phillips farm was located on Hanceville fine sandy loam, a mountain top soil in Cleburne County. The topography, however, was only gently undulating. The largest increases were obtained with the use of complete fertilizer. These increases, however, did not pay for the fertilizers used, the most profitable increase being produced by acid phosphate.

The test with sweet sorghum carried on by Best-Clymer Manufacturing Company, South Fort Smith, was placed on thin silt loam valley land of undulating topography, east of South Fort Smith. Acid phosphate gave the most profitable returns on the money invested, although the largest increases were produced by a fertilizer containing nitrogen in addition, and by an application of a fertilizer carrying all three elements. Manure and ground limestone also produced good increases.

The tests at the Burdette Plantation were located on fertile Sharkey clay loam, a commonly occurring soil in the Mississippi bottom. The test with cotton would appear to indicate that potash could be used profitably on this soil. The results on the whole are rather erratic. The test with corn on this same soil indicates that fertilization of a corn crop on the richer lands rather recently brought under cultivation is a questionable procedure.

The test with corn near Hazen, Prairie County, was located on the farm of L. D. Atkins, on the typical light colored silt loam timbered soil of the prairie section. The largest increases were produced from manure reinforced with acid phosphate, and by application of complete fertilizers. The increase produced by the heavy application of complete fertilizer was not a profitable one.

#### SEASON 1920.

The season of 1920 started in entirely too wet for good preparation of the soil. This wet condition continued throughout most of the growing season in the Delta section and in portions of the hill section as well. Some of the crops on tests located on soils in hill sections that had little water holding capacity were cut short on account of lack of moisture. In the Delta section in some cases at least three attempts were made to get a good stand.

The test on cotton carried out by Lee Lawrence, at DeQueen, Sevier County, was located on Ochlockonee fine sandy loam, a light brown fine sandy loam bottom soil. The test showed a ready response to applications of manure, and somewhat smaller effects due to the application of complete fertilizer, or combinations of two elements. The largest increases were produced by applications of manure.

The test on the farm of Mr. J. Floyd Fish, Lincoln County, being almost completely surrounded by woods, was badly damaged by an attack of boll weevil and this together with the fact that the soil was not very uniform tended to vitiate the results.

The cotton test on the farm of D. Petty, Logan County, was located on Pope fine sandy loam, a creek bottom soil. Following a heavy rain after the cotton was several inches high, the lower lying portions of the test, that is the first four plats and a portion of Plat No. 5, were overflowed. It is possible that this effected the yields of these plats. The largest increases were pro-

## COSATAL PLAINS SOIL

| Plot No. | Treatment Per Acre                                                                     | SEED COTTON                              |                  |                                              |                  |
|----------|----------------------------------------------------------------------------------------|------------------------------------------|------------------|----------------------------------------------|------------------|
|          |                                                                                        | Glenn Wallace<br>Lee Lawrence<br>DeQueen |                  | W. A. Trussell<br>J. Floyd Fish<br>Star City |                  |
|          |                                                                                        | Yield Per<br>A. Lbs.                     | Increase<br>Lbs. | Yield Per<br>A. Lbs.                         | Increase<br>Lbs. |
| 1        | None -----                                                                             | *1010                                    | ----             | 390                                          | ----             |
| 2        | 100 lbs. 15% Nitrate of Soda-----                                                      | 910                                      | 40               | 410                                          | 10               |
| 3        | 250 lbs. 16% Acid Phosphate-----                                                       | 960                                      | 90               | 430                                          | 10               |
| 4        | 30 lbs. 50% Potash-----                                                                | 930                                      | 60               | 460                                          | 30               |
| 5        | None -----                                                                             | 870                                      | ----             | 440                                          | ----             |
| 6        | 10 Tons Well Rotted Manure-----                                                        | 1420                                     | 590              | 550                                          | 90               |
| 7        | 250 lbs. 16% Acid Phosphate<br>100 lbs. 15% Nitrate of Soda-----                       | 930                                      | 150              | 610                                          | 140              |
| 8        | 100 lbs. 15% Nitrate of Soda<br>30 lbs. 50% Potash-----                                | 820                                      | 80               | 560                                          | 70               |
| 9        | None -----                                                                             | 690                                      | ----             | 510                                          | ----             |
| 10       | 250 lbs. 16% Acid Phosphate<br>30 lbs. 50% Potash-----                                 | 910                                      | 210              | 640                                          | 90               |
| 11       | 100 lbs. 15% Nitrate of Soda<br>250 lbs. 16% Acid Phosphate-----<br>30 lbs. 50% Potash | 830                                      | 120              | 650                                          | 70               |
| 12       | 250 lbs. 16% Acid Phosphate<br>10 Tons Well Rotted Manure-----                         | 1220                                     | 500              | 680                                          | 60               |
| 13       | None -----                                                                             | 730                                      | ----             | 660                                          | ----             |
| 14       | 200 lbs. 15% Nitrate of Soda<br>500 lbs. 16% Acid Phosphate-----<br>60 lbs. 50% Potash | 1090                                     | 370              | 730                                          | 90               |
| 15       | 100 lbs. 15% Nitrate of Soda<br>applied on 15 inch plants-----                         | 820                                      | 110              | 690                                          | 70               |
| 16       | 2000 lbs. Crushed Limestone-----                                                       | ----                                     | ----             | ----                                         | ----             |
| 17       | None -----                                                                             | 690                                      | ----             | 590                                          | ----             |

\*Note: 50% boll weevil damage in test with J. Floyd Fish.

duced by the applications of complete fertilizers, acid phosphate used alone, and in connection with nitrate of soda. No manure was used in these tests.

The tests on the farm of Mr. Matt Schaible, Crawford County, was located on Conway very fine sandy loam, a gray colored soil of rather poor drainage. The stand obtained was rather irregular. Complete fertilizers and manure reinforced with acid phosphate gave the largest increases. Such land needs draining before the best results can be obtained from the use of any fertilizers.

The test on the farm of H. A. Lafavers, Fulton County, was located on sandy loam upland typical of that section of the state.

# RESULTS OF FERTILIZER EXPERIMENTS

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## HILL SOIL

| Plot No. | Treatment Per Acre                                     | SEED COTTON                         |                   |                                           |              |                                             |              |                                    |              |                                       |              |                         |              |
|----------|--------------------------------------------------------|-------------------------------------|-------------------|-------------------------------------------|--------------|---------------------------------------------|--------------|------------------------------------|--------------|---------------------------------------|--------------|-------------------------|--------------|
|          |                                                        | M. C. Ferguson<br>D. Petty<br>Paris |                   | L. F. Keith<br>Malt Schauble<br>Van Buren |              | S. Kennedy<br>S. E. Powell<br>Heber Springs |              | S. Kennedy<br>J. W. Owens<br>Tyler |              | Fred Moore<br>H. A. Latevers<br>Viola |              |                         |              |
|          |                                                        | Yield<br>Per A.<br>Lbs.             | In-crease<br>Lbs. | Yield<br>Per A.<br>Lbs.                   | Inc.<br>Lbs. | Yield<br>Per A.<br>Lbs.                     | Inc.<br>Lbs. | Yield<br>Per A.<br>Lbs.            | Inc.<br>Lbs. | Yield<br>Per A.<br>Lbs.               | Inc.<br>Lbs. | Yield<br>Per A.<br>Lbs. | Inc.<br>Lbs. |
| 1        | None                                                   | 1100                                | ---               | 1300                                      | ---          | 700                                         | ---          | 760                                | ---          | *560                                  | ---          | ---                     | ---          |
| 2        | 100 lbs. 15% Nitrate of Soda                           | 1210                                | 170               | 1320                                      | 0            | 890                                         | 90           | 810                                | ---          | 1060                                  | ---          | 130                     | ---          |
| 3        | 250 lbs. 16% Acid Phosphate                            | 1220                                | 250               | 1260                                      | -80          | 1000                                        | 100          | 970                                | 120          | 1230                                  | ---          | 300                     | ---          |
| 4        | 30 lbs. 50% Potash                                     | 1030                                | 130               | 1520                                      | 160          | 1150                                        | 150          | 1080                               | 180          | 1100                                  | ---          | 170                     | ---          |
| 5        | None                                                   | 830                                 | ---               | 1370                                      | ---          | 1090                                        | ---          | 950                                | ---          | 930                                   | ---          | ---                     | ---          |
| 6        | 10 Tons well rotted manure                             | (No Manure)                         | ---               | 1530                                      | 140          | 2260                                        | 1160         | 1310                               | 360          | 1070                                  | ---          | 140                     | ---          |
| 7        | 250 lbs. 16% Acid Phosphate                            | 1060                                | 240               | 1430                                      | 10           | 1520                                        | 410          | 1310                               | 360          | 1200                                  | ---          | 270                     | ---          |
| 8        | 100 lbs. 15% Nitrate of Soda                           | 960                                 | 140               | 1460                                      | 20           | 1760                                        | 640          | 1250                               | 310          | 1220                                  | ---          | 290                     | ---          |
| 9        | 30 lbs. 50% Potash                                     | 810                                 | ---               | 1460                                      | ---          | 1130                                        | ---          | 940                                | ---          | 930                                   | ---          | ---                     | ---          |
| 10       | None                                                   | ---                                 | ---               | ---                                       | ---          | ---                                         | ---          | ---                                | ---          | ---                                   | ---          | ---                     | ---          |
| 11       | 250 lbs. 16% Acid Phosphate                            | 980                                 | 220               | 1510                                      | 30           | 1710                                        | 600          | 1390                               | 490          | 1410                                  | ---          | 430                     | ---          |
| 12       | 100 lbs. 15% Nitrate of Soda                           | 1080                                | 370               | 1760                                      | 250          | 1770                                        | 690          | 1240                               | 370          | 1380                                  | ---          | 340                     | ---          |
| 13       | 250 lbs. 16% Acid Phosphate                            | (No Manure)                         | ---               | 1780                                      | 250          | 2010                                        | 950          | 1300                               | 470          | 1500                                  | ---          | 400                     | ---          |
| 14       | 10 Tons well rotted manure                             | 610                                 | ---               | 1550                                      | ---          | 1040                                        | ---          | 800                                | ---          | 1150                                  | ---          | ---                     | ---          |
| 15       | None                                                   | ---                                 | ---               | ---                                       | ---          | ---                                         | ---          | ---                                | ---          | ---                                   | ---          | ---                     | ---          |
| 16       | 200 lbs. 15% Nitrate of Soda                           | 990                                 | 360               | ---                                       | ---          | 1440                                        | 400          | 1450                               | 720          | 1400                                  | ---          | 290                     | ---          |
| 17       | 60 lbs. 50% Potash                                     | 530                                 | -120              | ---                                       | ---          | 1520                                        | 480          | 830                                | 160          | 1180                                  | ---          | 110                     | ---          |
| 18       | 100 lbs. 15% Nitrate of Soda applied on 15-inch plants | 680                                 | ---               | ---                                       | ---          | 1410                                        | 370          | 630                                | 20           | 1220                                  | ---          | 170                     | ---          |
| 19       | 2000 lbs. Crushed Limestone                            | ---                                 | ---               | ---                                       | ---          | *540                                        | ---          | 540                                | ---          | 980                                   | ---          | ---                     | ---          |
| 20       | None                                                   | ---                                 | ---               | ---                                       | ---          | ---                                         | ---          | ---                                | ---          | ---                                   | ---          | ---                     | ---          |

\*Not used in calculating.

## HILL SOIL

| Plot No. | Treatment per Acre           | CORN                                |             |                                         |             |                                              |             | SORGHUM (SWEET)                          |              |
|----------|------------------------------|-------------------------------------|-------------|-----------------------------------------|-------------|----------------------------------------------|-------------|------------------------------------------|--------------|
|          |                              | M. C. Ferguson<br>D. Petty<br>Paris |             | L. F. Keith<br>H. Richmond<br>Van Buren |             | S. Kennedy<br>Jobe Phillips<br>Heber Springs |             | Best-Clymer<br>Mfg. Co.<br>S. Fort Smith |              |
|          |                              | Yield<br>Per A.<br>Bu.              | Inc.<br>Bu. | Yield<br>Per A.<br>Bu.                  | Inc.<br>Bu. | Yield<br>Per A.<br>Bu.                       | Inc.<br>Bu. | Yield<br>Per A.<br>Tons                  | Inc.<br>Tons |
| 1        | None                         | 22.3                                | ---         | 4.4                                     | ---         | 21.0                                         | ---         | 1.73                                     | ---          |
| 2        | 100 lbs. 15% Nitrate of Soda | 30.6                                | 8.4         | 8.0                                     | 4.2         | 26.4                                         | 5.5         | 2.55                                     | .41          |
| 3        | 250 lbs. 16% Acid Phosphate  | 26.0                                | 3.8         | 5.6                                     | 2.4         | 26.4                                         | 6.7         | 2.01                                     | .37          |
| 4        | 30 lbs. 50% Potash           | 20.1                                | -2.0        | 3.4                                     | .7          | 23.2                                         | 2.7         | 3.55                                     | ---          |
| 5        | None                         | 22.0                                | ---         | 2.1                                     | ---         | 20.4                                         | ---         | 3.40                                     | ---          |
| 6        | 10 Tons Well Rotted Manure   | 29.7                                | 7.8         | 8.7                                     | 6.3         | 35.1                                         | 14.9        | 3.50                                     | .05          |
| 7        | 250 lbs. 16% Acid Phosphate  | 31.7                                | 9.9         | 7.0                                     | 4.3         | 27.4                                         | 7.4         | 4.35                                     | .85          |
| 8        | 100 lbs. 15% Nitrate of Soda | 31.0                                | 9.3         | 8.0                                     | 4.9         | 21.9                                         | 2.0         | 3.85                                     | .30          |
| 9        | 30 lbs. 50% Potash           | 21.6                                | ---         | 3.4                                     | ---         | 19.7                                         | ---         | 3.60                                     | ---          |
| 10       | 250 lbs. 16% Acid Phosphate  | 27.3                                | .5          | 6.1                                     | 2.3         | 17.3                                         | -2.2        | 6.85                                     | 2.83         |
| 11       | 100 lbs. 15% Nitrate of Soda | 30.1                                | -1.9        | 10.9                                    | 6.6         | 24.3                                         | 5.0         | 6.15                                     | 1.71         |
| 12       | 250 lbs. 16% Acid Phosphate  | 41.7                                | 4.5         | 9.7                                     | 5.0         | 24.5                                         | 5.5         | 8.83                                     | 3.96         |
| 13       | 10 Tons Well Rotted Manure   | *42.4                               | ---         | 5.1                                     | ---         | 18.8                                         | ---         | 5.70                                     | ---          |
| 14       | 200 lbs. 15% Nitrate of Soda | 50.3                                | 15.4        | 11.3                                    | 6.2         | 27.8                                         | 9.1         | 7.35                                     | 1.85         |
| 15       | 500 lbs. 16% Acid Phosphate  | 21.6                                | -5.9        | 9.1                                     | 3.8         | 22.3                                         | 3.8         | 5.78                                     | .48          |
| 16       | 100 lbs. 15% Nitrate of Soda | 20.1                                | ---         | 5.9                                     | ---         | 18.2                                         | ---         | 5.13                                     | ---          |
| 17       | 2000 lbs. Crushed Limestone  | ---                                 | ---         | ---                                     | ---         | ---                                          | ---         | ---                                      | ---          |

\*Old building lot affected 12, 13, and 14.

## DELTA SOIL

| Plot No. |   | Treatment Per Acre | SEED COTTON                                |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|----------|---|--------------------|--------------------------------------------|--------------|-------------------------|------------------------------------------|-------------------------|--------------|--------------------------------------------|--------------|-------------------------|-------------------------------------------|-------------------------|--------------|---------------------------------------------|--------------|--|
|          |   |                    | A. P. Reynolds<br>J. E. Hollan<br>Levesque |              |                         | E. B. Whitaker<br>Ben Reaves<br>Marianna |                         |              | E. B. Whitaker<br>M. C. Graham<br>Marianna |              |                         | Burdette<br>Plantation,<br>Burdette, Ark. |                         |              | E. S. Barrentine<br>M. M. Morrison<br>Earle |              |  |
|          |   |                    | Yield<br>Per A.<br>Lbs.                    | Inc.<br>Lbs. | Yield<br>Per A.<br>Lbs. | Inc.<br>Lbs.                             | Yield<br>Per A.<br>Lbs. | Inc.<br>Lbs. | Yield<br>Per A.<br>Lbs.                    | Inc.<br>Lbs. | Yield<br>Per A.<br>Lbs. | Inc.<br>Lbs.                              | Yield<br>Per A.<br>Lbs. | Inc.<br>Lbs. | Yield<br>Per A.<br>Lbs.                     | Inc.<br>Lbs. |  |
| 1        | 2 | 3                  | 4                                          | 5            | 6                       | 7                                        | 8                       | 9            | 10                                         | 11           | 12                      | 13                                        | 14                      | 15           | 16                                          | 17           |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |
|          |   |                    |                                            |              |                         |                                          |                         |              |                                            |              |                         |                                           |                         |              |                                             |              |  |

\*Not used in calculating.

## DELTA SOIL

| Plot No. | Treatment Per Acre                                                                     | CORN                                      |                 |                                            |                 |
|----------|----------------------------------------------------------------------------------------|-------------------------------------------|-----------------|--------------------------------------------|-----------------|
|          |                                                                                        | M. W. Muldrow<br>Victor Wright<br>Piggott |                 | A. P. Reynolds<br>J. E. Holian<br>Levesque |                 |
|          |                                                                                        | Yield Per<br>A. Bu.                       | Increase<br>Bu. | Yield Per<br>A. Bu.                        | Increase<br>Bu. |
| 1        | None -----                                                                             | 34.9                                      | ---             | 13.9                                       | ---             |
| 2        | 100 lbs. 15% Nitrate of Soda-----                                                      | 47.5                                      | 10.2            | 14.7                                       | .9              |
| 3        | 250 lbs. 16% Acid Phosphate-----                                                       | 46.7                                      | 7.0             | 23.3                                       | 9.7             |
| 4        | 30 lbs. 50% Potash-----                                                                | 47.3                                      | 5.2             | 12.4                                       | -1.0            |
| 5        | None -----                                                                             | 44.6                                      | ---             | 13.3                                       | ---             |
| 6        | 10 Tons Well Rotted Manure-----                                                        | 55.7                                      | 10.8            | ---                                        | ---             |
| 7        | 250 lbs. 16% Acid Phosphate<br>100 lbs. 15% Nitrate of Soda-----                       | 51.3                                      | 6.0             | 15.1                                       | 1.4             |
| 8        | 100 lbs. 15% Nitrate of Soda<br>30 lbs. 50% Potash-----                                | 57.0                                      | 11.3            | 11.1                                       | 2.8             |
| 9        | None -----                                                                             | *53.7                                     | ---             | 14.1                                       | ---             |
| 10       | 250 lbs. 16% Acid Phosphate<br>30 lbs. 50% Potash-----                                 | 49.5                                      | 3.0             | 18.9                                       | 4.7             |
| 11       | 100 lbs. 15% Nitrate of Soda<br>250 lbs. 16% Acid Phosphate-----<br>30 lbs. 50% Potash | 57.5                                      | 10.6            | 13.7                                       | -.5             |
| 12       | 250 lbs. 16% Acid Phosphate<br>10 Tons Well Rotted Manure-----                         | 53.6                                      | 6.3             | ---                                        | ---             |
| 13       | None -----                                                                             | 47.6                                      | ---             | 14.4                                       | ---             |
| 14       | 200 lbs. 15% Nitrate of Soda<br>500 lbs. 16% Acid Phosphate-----<br>60 lbs. 50% Potash | 57.7                                      | 10.4            | 12.0                                       | -2.1            |
| 15       | 100 lbs 15% Nitrate of Soda<br>applied on 15 inch plants-----                          | 53.0                                      | 5.7             | 13.4                                       | -.4             |
| 16       | 2000 lbs. Crushed Limestone-----                                                       | ---                                       | ---             | ---                                        | ---             |
| 17       | None -----                                                                             | 46.1                                      | ---             | 13.1                                       | ---             |

\*Fence Row.

All fertilizers applied gave at least some increase. The largest increase was obtained by the use of acid phosphate along with some potash, with manure and acid phosphate ranking second. Crushed limestone shows an increase worth while.

The test on the E. E. Powell farm, in Cleburne County, was located on Waynesboro loam which is second bottom land. The value of manure is again strongly brought out in this test, ten tons of manure doubling the yield of seed cotton. All of the fertilizer treatments show an increased production of seed cotton. The treatments with manure gave the largest increases, followed by lighter application of complete fertilizers. Crushed limestone also shows a profitable increase.

The soil on which the test on the farm of J. W. Owens, Cleburne County, was located was the Hanceville fine sandy loam, a commonly occurring type in the hill sections. All of the treatments with one exception showed increases in seed cotton produced. The largest increase of seed cotton was produced by the heavy application of complete fertilizers, which practically doubled the yield. Other good increases were produced by manure reinforced with acid phosphate, nitrate of soda and acid phosphate, and acid phosphate and potash.

The test with corn on the farm of D. Petty, in Logan County, was located on valley phase of the Hanceville fine sandy loam. Unfortunately, an old building lot effected a portion of three of these plats and it is difficult to get at the true value of the fertilizers in this portion of the test. Plat No. 12 was slightly affected, and plats No. 13 and 14 considerably affected by this old building lot. Probably in computing the increase on plat No. 11 it would have been better to have used a yield of  $21\frac{1}{2}$  bushels of corn as an average of all the other checks with the exception of plat No. 13, which would have given an increase for plat No. 11 of 8.3 bushels instead of the -1.9 bushels. The increase shown from the use of ten tons of manure and 250 pounds of acid phosphate is also too low, but as this was one of the plats affected by the building lot no better figures can be suggested. The test at least indicates a ready response to the use of nitrogen and phosphoric acid.

The test with corn on the farm of Henry Richmond, in Crawford County, was located on Hanceville fine sandy loam. It was located on a thin hillside. This soil was not in condition to stand dry weather, and during a dry spell of rather short duration the yield was cut down to a considerable extent. The results indicate a ready response to the use of manure and complete fertilizers, although the yields obtained even with these treatments are not profitable yields.

The test with corn on the farm of Jobe Phillips, Cleburne County, was located on Hanceville fine sandy loam, a commonly occurring type in the hill sections. All treatments with one exception, showed an increase. The largest increase was produced by manure. The most profitable increase was produced by acid phosphate.

The sorghum test carried out by the Best-Clymer Manufacturing Company was located on the same field that was used the year previous. The soil was silt loam valley land east of South Fort Smith. The largest increase was produced by manure reinforced with acid phosphate. Acid phosphate gave the most profitable increase. Other profitable increases were produced by acid phosphate and potash, and by application of lime.

The test on the Burdette Plantation, Mississippi County, were located on Sharkey clay. This soil is naturally a fertile



soil and has been under cultivation a relatively short time. This field was somewhat billowy with occasional sand blows. During excessive wet weather in early summer this unevenness of surface accentuated the drainage difficulties. The cotton started off well on the higher areas, but drowned out in the lower areas. Little definite information can be gained from a study of these results.

The test on the farm of Mr. J. E. Hollan, Cross County, was located on Lintonia fine sandy loam, a light brown terrace soil. Repeated attempts were made to obtain a good stand, but the stand obtained was only fair. The excessive wet weather made proper cultivation very difficult. This test indicates, as do several other tests carried on in the Delta section, that there are many years when application of fertilizers does not pay.

The test on the farm of Ben Reaves, Lee County, was located on sandy loam typical of this section of the state. The largest increases were obtained by heavy application of complete fertilizers and by the use of manure. The most profitable increases, however, were produced by applications of nitrate of soda and acid phosphate combined.

The test carried out by Mr. M. C. Graham on the Hewitt farm, Lee County, was located on Lintonia fine sandy loam. The largest increase was produced by manure reinforced with acid phosphate, the next largest increase being obtained by the heavy application of complete fertilizers. The most profitable increase, however, was produced by the application of acid phosphate.

The test on the farm of M. M. Morrison, Crittenden County, was located on Sharkey very fine sandy loam. All treatments with one exception gave increased yields. Heavy applications of complete fertilizer gave the largest increase, while the use of acid phosphate gave the most profitable one. A poor stand on plat No. 2 accounts for the low yield obtained here. It is unfortunate that we have no yield on check plat 17. From the topography of the field there is no question but that there is rather rapid increase of fertility from plat No. 13 on toward 17. It is possible that the increase shown for plat No. 14 is somewhat too high, and very likely the increase shown on plat 15 is considerably too high.

The test with corn on the farm of Mr. Wright, Clay County, was located on Sharkey clay loam which contained a considerable amount of sand. The results indicate the need of nitrogen and of phosphoric acid.

The test with corn on the farm of J. F. Hollan was located on Lintonia fine sandy loam. Due to the very wet weather, even after three plantings, only about half a stand was obtained and this was rather irregular. Climatic conditions had greater effect on yields than had additions of plant food.

## SEASON 1921.

The cropping season of 1921 was somewhat late, several late periods of cold occurring. Heavy rainfall also occurred near the time of planting. The summer season was extremely dry in the eastern part of the state, some areas in southeastern Arkansas not receiving a good rain from the time the crop was planted until it was matured. In the western portion of the state the rainfall was better distributed throughout the summer season, and conditions of growth were much more favorable, although even here periods of excessive moisture were followed by periods of decidedly dry weather.

Boll weevil infestation was more widespread than at any time previous, and more severe. In late summer the caterpillar did some damage, these two pests completely ruining some tests. The southwest portion of the state suffered the heaviest damage.

The test with cotton carried out on the farm of Mr. J. W. Owens, Cleburne County, was located on Hanceville fine sandy loam, one of the typical soils of the hill section of the state. All of the fertilizer treatments, with the exception of late application of nitrate of soda, gave some increase. It is not to be expected that late application of nitrate of soda under weevil conditions will produce much increase. It will be noted that several of the treatments doubled the yield of seed cotton produced, the largest increase being produced by manure reinforced with acid phosphate, followed in order by the heavy application of complete fertilizer, and the manure used alone. The lighter application of complete fertilizer gave a good return on the money invested, although the use of acid phosphate was the most profitable treatment.

The test with cotton on the farm of Mr. E. E. Powell, Cleburne County, was located on Hanceville loam. All fertilizer treatments, with one exception, gave some increase. The largest increase was produced by farm manure reinforced with acid phosphate, and the second largest increase was produced by the complete fertilizer treatment, although the most profitable increase was produced by the use of acid phosphate.

The test with cotton on the farm of Mr. A. E. Poole, Faulkner County, as located on sandy loam, upland typical of this section of the state. All fertilizer treatments gave some increase, the largest increase being produced by the heavy application of complete fertilizer, and the second largest increase being produced by manure reinforced with acid phosphate. Several of the treatments more than doubled the yield of seed cotton produced. The increases produced by nitrate of soda and acid phosphate used alone were the most profitable increases.

The test with cotton on the farm of Mr. G. M. Cravens, Logan County, was located on Hanceville fine sandy loam. All of

## HILL SOIL

| Plot No. | Treatment Per Acre                                     | SEED COTTON                        |              |                                                            |              |                                             |              |                                                |              |                                              |              |  |  |
|----------|--------------------------------------------------------|------------------------------------|--------------|------------------------------------------------------------|--------------|---------------------------------------------|--------------|------------------------------------------------|--------------|----------------------------------------------|--------------|--|--|
|          |                                                        | S. Kennedy<br>J. W. Owens<br>Tyler |              | S. Kennedy +<br>E. E. Powell <sup>1</sup><br>Heber Springs |              | T. M. Williams<br>A. E. Poole<br>Greenbrier |              | S. W. Houston<br>G. M. Cravens<br>Prairie View |              | J. W. Sargent<br>R. D. Blazer<br>Little Rock |              |  |  |
|          |                                                        | Yield<br>Per A.<br>Lbs.            | Inc.<br>Lbs. | Yield<br>Per A.<br>Lbs.                                    | Inc.<br>Lbs. | Yield<br>Per A.<br>Lbs.                     | Inc.<br>Lbs. | Yield<br>Per A.<br>Lbs.                        | Inc.<br>Lbs. | Yield<br>Per A.<br>Lbs.                      | Inc.<br>Lbs. |  |  |
| 1        | No treatment                                           | 520                                | ---          | 1010                                                       | ---          | 400                                         | ---          | 360                                            | ---          | 200                                          | ---          |  |  |
| 2        | 100 lbs. 15% Nitrate of Soda                           | 580                                | 60           | 1290                                                       | 260          | 750                                         | 320          | 480                                            | 80           | 220                                          | 20           |  |  |
| 3        | 250 lbs. 16% Acid Phosphate                            | 980                                | 460          | 1370                                                       | 310          | 750                                         | 280          | 790                                            | 380          | 210                                          | 20           |  |  |
| 4        | 30 lbs. 50% Potash                                     | 540                                | 20           | 1200                                                       | 120          | 660                                         | 150          | 570                                            | 140          | 200                                          | 20           |  |  |
| 5        | No treatment                                           | 520                                | ---          | 1100                                                       | ---          | 540                                         | ---          | 460                                            | ---          | 180                                          | ---          |  |  |
| 6        | 10 Tons well rotted manure                             | 1030                               | 540          | 1400                                                       | 280          | 670                                         | 160          | ---                                            | ---          | 250                                          | 70           |  |  |
| 7        | 100 lbs. 15% Nitrate of Soda                           | 940                                | 480          | 1470                                                       | 320          | *810                                        | 340          | 1120                                           | 680          | 220                                          | 50           |  |  |
| 8        | 250 lbs. 16% Acid Phosphate                            | 720                                | 290          | 1210                                                       | 30           | 790                                         | 360          | 650                                            | 220          | 210                                          | 50           |  |  |
| 9        | 30 lbs. 50% Potash                                     | 410                                | ---          | 1200                                                       | ---          | 400                                         | ---          | 390                                            | ---          | 160                                          | ---          |  |  |
| 10       | No treatment                                           | 850                                | 430          | 1310                                                       | 130          | 730                                         | 320          | 790                                            | 380          | 210                                          | 60           |  |  |
| 11       | 250 lbs. 16% Acid Phosphate                            | 930                                | 490          | 1540                                                       | 380          | 880                                         | 450          | 1020                                           | 580          | 240                                          | 100          |  |  |
| 12       | 100 lbs. 15% Nitrate of Soda                           | 1040                               | 590          | 1560                                                       | 420          | 970                                         | 530          | 1070                                           | 580          | 240                                          | 110          |  |  |
| 13       | 250 lbs. 16% Acid Phosphate                            | 460                                | ---          | 1120                                                       | ---          | 450                                         | ---          | 590                                            | ---          | 120                                          | ---          |  |  |
| 14       | 10 Tons well rotted manure                             | 1010                               | 550          | 1440                                                       | 320          | 1000                                        | 570          | 1260                                           | 720          | 280                                          | 140          |  |  |
| 15       | No treatment                                           | 460                                | ---          | 1120                                                       | ---          | ---                                         | ---          | ---                                            | ---          | ---                                          | ---          |  |  |
| 16       | 200 lbs. 15% Nitrate of Soda                           | 460                                | 0            | 1120                                                       | ---          | ---                                         | ---          | ---                                            | ---          | 210                                          | 50           |  |  |
| 17       | 500 lbs. 16% Acid Phosphate                            | ---                                | ---          | ---                                                        | ---          | 520                                         | 110          | ---                                            | ---          | ---                                          | ---          |  |  |
| 18       | 60 lbs. 50% Potash                                     | ---                                | ---          | ---                                                        | ---          | 390                                         | ---          | ---                                            | ---          | 170                                          | ---          |  |  |
| 19       | 100 lbs. 15% Nitrate of Soda applied on 15-inch plants | ---                                | ---          | ---                                                        | ---          | ---                                         | ---          | ---                                            | ---          | ---                                          | ---          |  |  |
| 20       | 1 Ton Ground Limestone                                 | ---                                | ---          | ---                                                        | ---          | ---                                         | ---          | ---                                            | ---          | ---                                          | ---          |  |  |
| 21       | No treatment                                           | ---                                | ---          | ---                                                        | ---          | ---                                         | ---          | ---                                            | ---          | ---                                          | ---          |  |  |

\*Late application of 100 lbs. nitrate also.

## RESULTS OF FERTILIZER EXPERIMENTS

17

## HILL SOIL

| Plot No. | Treatment Per Acre                                                                    | CORN                                  |                      |                                            |                      |                                              |                      |
|----------|---------------------------------------------------------------------------------------|---------------------------------------|----------------------|--------------------------------------------|----------------------|----------------------------------------------|----------------------|
|          |                                                                                       | B. A. Spradlin<br>N. Cook<br>Harrison |                      | B. A. Spradlin<br>Wycoff Bros.<br>Harrison |                      | S. Kennedy<br>Jobe Phillips<br>Heber Springs |                      |
|          |                                                                                       | Yield<br>Per A.<br>Bu.                | In-<br>crease<br>Bu. | Yield<br>Per A.<br>Bu.                     | In-<br>crease<br>Bu. | Yield<br>Per A.<br>Bu.                       | In-<br>crease<br>Bu. |
| 1        | None -----                                                                            | 15.3                                  | ---                  | 16.9                                       | ---                  | 17.7                                         | ---                  |
| 2        | 100 lbs. 15% Nitrate of Soda----                                                      | 21.7                                  | 5.7                  | 12.6                                       | -5.1                 | 24.3                                         | 6.1                  |
| 3        | 250 lbs. 16% Acid Phosphate----                                                       | 22.6                                  | 5.9                  | 22.0                                       | 3.5                  | 25.1                                         | 6.4                  |
| 4        | 30 lbs. 50% Potash-----                                                               | 18.4                                  | 1.0                  | 21.4                                       | 2.2                  | 22.9                                         | 3.7                  |
| 5        | None -----                                                                            | 18.1                                  | ---                  | 20.0                                       | ---                  | 19.7                                         | ---                  |
| 6        | 10 Tons Well Rotted Manure----                                                        | 26.6                                  | 9.4                  | 29.6                                       | 10.1                 | 31.9                                         | 13.0                 |
| 7        | 100 lbs. 15% Nitrate of Soda<br>250 lbs. 16% Acid Phosphate----                       | 18.1                                  | 1.7                  | 33.0                                       | 14.0                 | 26.3                                         | 8.3                  |
| 8        | 100 lbs. 15% Nitrate of Soda<br>30 lbs. 50% Potash-----                               | 17.6                                  | 2.0                  | 20.3                                       | 1.8                  | 19.0                                         | 1.8                  |
| 9        | None -----                                                                            | 14.7                                  | ---                  | 17.9                                       | ---                  | 16.4                                         | ---                  |
| 10       | 250 lbs. 16% Acid Phosphate<br>30 lbs. 50% Potash-----                                | 12.4                                  | -1.6                 | 27.0                                       | 9.0                  | 18.9                                         | 2.6                  |
| 11       | 100 lbs. 15% Nitrate of Soda<br>250 lbs. 16% Acid Phosphate----<br>30 lbs. 50% Potash | 14.6                                  | .7                   | 30.1                                       | 12.0                 | 19.0                                         | 2.8                  |
| 12       | 250 lbs. 16% Acid Phosphate<br>10 Tons Well Rotted Manure----                         | 20.7                                  | 8.1                  | 36.9                                       | 18.9                 | 24.4                                         | 8.3                  |
| 13       | None -----                                                                            | 11.9                                  | ---                  | 18.0                                       | ---                  | 16.0                                         | ---                  |
| 14       | 200 lbs. 15% Nitrate of Soda<br>500 lbs. 16% Acid Phosphate----<br>60 lbs. 50% Potash | 22.0                                  | 10.2                 | 27.1                                       | 10.7                 | 22.4                                         | 6.4                  |
| 15       | 100 lbs. 15% Nitrate of Soda<br>applied on 15 inch plants-----                        | 20.3                                  | 8.6                  | 14.3                                       | -5                   | 17.0                                         | 1.0                  |
| 16       | 1000 lbs. Air Slaked Lime-----                                                        | ---                                   | ---                  | 17.4                                       | 4.2                  | ---                                          | ---                  |
| 17       | None -----                                                                            | 11.4                                  | ---                  | 11.7                                       | ---                  | ---                                          | ---                  |

the fertilizer treatments showed some increase, the largest increase being produced by the heavy application of complete fertilizer. Manure was not used in this test. Several of the treatments more than double the yield of seed cotton. The most profitable increases were produced by acid phosphate alone, and by acid phosphate and nitrate of soda used together.

The test with cotton on the farm of Mr. R. D. Blazer, Pulaski County, was located on Hanceville loam. Weevil infestation was very severe, and very little cotton was produced. Although some increase was produced in all cases, none of these increases were profitable ones.

The test with corn on the farm of Mr. N. Cook, Boone County, was located on commonly occurring upland soil in this sec-

## HILL SOIL

| Plot No. | Treatment Per Acre                                                                     | CORN                                           |                      |                                              |                      | SORGHUM (SWEET)                           |                       |
|----------|----------------------------------------------------------------------------------------|------------------------------------------------|----------------------|----------------------------------------------|----------------------|-------------------------------------------|-----------------------|
|          |                                                                                        | S. W. Houston<br>G. M. Cravens<br>Prairie View |                      | J. W. Sargent<br>R. D. Blazer<br>Little Rock |                      | Temtor Pro-<br>ducts Co.<br>So. Ft. Smith |                       |
|          |                                                                                        | Yield<br>Per A.<br>Bu.                         | In-<br>crease<br>Bu. | Yield<br>Per A.<br>Bu.                       | In-<br>crease<br>Bu. | Yield<br>Per A.<br>Tons                   | In-<br>crease<br>Tons |
| 1        | None -----                                                                             | 14.4                                           | ---                  | 15.7                                         | ---                  | 5.3                                       | ---                   |
| 2        | 100 lbs. 15% Nitrate of Soda-----                                                      | 18.7                                           | 3.3                  | 17.4                                         | 1.7                  | 5.9                                       | .64                   |
| 3        | 250 lbs. 16% Acid Phosphate-----                                                       | 15.9                                           | .9                   | 17.1                                         | 1.4                  | 6.65                                      | 1.43                  |
| 4        | 30 lbs. 50% Potash-----                                                                | 15.9                                           | 1.2                  | 17.9                                         | 2.3                  | 5.75                                      | .58                   |
| 5        | None -----                                                                             | 15.7                                           | ---                  | 15.6                                         | ---                  | 5.13                                      | ---                   |
| 6        | 10 Tons Well Rotted Manure-----                                                        | ---                                            | ---                  | 19.4                                         | 3.8                  | 8.18                                      | 3.01                  |
| 7        | 100 lbs. 15% Nitrate of Soda<br>250 lbs. 16% Acid Phosphate-----                       | 26.7                                           | 10.9                 | 17.7                                         | 2.0                  | 8.73                                      | 3.53                  |
| 8        | 100 lbs. 15% Nitrate fo Soda<br>30 lbs. 50% Potash-----                                | 23.6                                           | 7.8                  | 17.6                                         | 1.8                  | 6.35                                      | 1.11                  |
| 9        | None -----                                                                             | 15.9                                           | ---                  | 15.9                                         | ---                  | 5.28                                      | ---                   |
| 10       | 250 lbs. 16% Acid Phosphate<br>30 lbs. 50% Potash-----                                 | 15.7                                           | 0                    | 17.6                                         | 1.7                  | 10.65                                     | 5.07                  |
| 11       | 100 lbs. 15% Nitrate of Soda<br>250 lbs. 16% Acid Phosphate-----<br>30 lbs. 50% Potash | 25.1                                           | 7.4                  | 18.6                                         | 2.8                  | 10.48                                     | 4.59                  |
| 12       | 250 lbs. 16% Acid Phosphate<br>10 Tons Well Rotted Manure-----                         | ---                                            | ---                  | 19.0                                         | 3.2                  | 11.53                                     | 5.34                  |
| 13       | None -----                                                                             | 23.4                                           | ---                  | 17.1                                         | ---                  | 6.5                                       | ---                   |
| 14       | 200 lbs. 15% Nitrate of Soda<br>500 lbs. 16% Acid Phosphate-----<br>60 lbs. 50% Potash | 36.1                                           | 14.6                 | 27.0                                         | 11.3                 | 9.35                                      | 2.72                  |
| 15       | 100 lbs. 15% Nitrate of Soda<br>applied on 15 inch plants-----                         | 29.4                                           | 6.0                  | 18.3                                         | 2.7                  | 7.68                                      | .78                   |
| 16       | 1 Ton Ground Limestone-----                                                            | ---                                            | ---                  | ---                                          | ---                  | 6.55                                      | -.21                  |
| 17       | None -----                                                                             | ---                                            | ---                  | 15.6                                         | ---                  | 7.03                                      | ---                   |

tion of the state. The largest increase was produced by the heavy application of complete fertilizer, and the second largest was produced by the use of manure. Acid phosphate and nitrate of soda used alone gave the largest increase per dollar invested, although assuming a value of sixty-five cents per bushel for corn the increase only slightly more than paid for the cost of application.

The test with corn on the farm of Wycoff Brothers, Boone County, was located on typical upland soil of medium fertility. The largest increase was produced by the use of manure reinforced with acid phosphate, and the second largest increase by the use of acid phosphate and nitrate of soda combined, this treatment giving the most profitable increase.

## DELTA SOIL

| Plot No. | Treatment Per Acre                                                                     | CORN                            |                      |                                           |                      |                                            |                      |
|----------|----------------------------------------------------------------------------------------|---------------------------------|----------------------|-------------------------------------------|----------------------|--------------------------------------------|----------------------|
|          |                                                                                        | Burdette Plantation<br>Burdette |                      | A. P. Reynolds<br>Therold Bailey<br>Wynne |                      | E. B. Whitaker<br>J. M. Hewitt<br>Marianna |                      |
|          |                                                                                        | Yield<br>Per A.<br>Bu.          | In-<br>crease<br>Bu. | Yield<br>Per A.<br>Bu.                    | In-<br>crease<br>Bu. | Yield<br>Per A.<br>Bu.                     | In-<br>crease<br>Bu. |
| 1        | None -----                                                                             | 47.4                            | ---                  | 19.0                                      | ---                  | ---                                        | ---                  |
| 2        | 100 lbs. 15% Nitrate of Soda-----                                                      | 44.0                            | -8.6                 | 23.9                                      | 4.1                  | 28.1                                       | -3.0                 |
| 3        | 250 lbs. 16% Acid Phosphate-----                                                       | 47.7                            | -10.2                | 23.3                                      | 2.8                  | 28.6                                       | -2.5                 |
| 4        | 30 lbs. 50% Potash-----                                                                | 52.7                            | -10.4                | 24.0                                      | 2.7                  | 26.0                                       | -5.1                 |
| 5        | None -----                                                                             | 68.3                            | ---                  | 22.1                                      | ---                  | 31.1                                       | ---                  |
| 6        | 10 Tons Well Rotted Manure-----                                                        | 69.3                            | 4.7                  | 35.6                                      | 14.4                 | ---                                        | ---                  |
| 7        | 100 lbs. 15% Nitrate of Soda<br>250 lbs. 16% Acid Phosphate-----                       | 63.7                            | 4.7                  | 23.7                                      | 3.4                  | 35.3                                       | 1.9                  |
| 8        | 100 lbs. 15% Nitrate of Soda<br>30 lbs. 50% Potash-----                                | 54.3                            | 0                    | 19.9                                      | .5                   | 31.7                                       | -3.9                 |
| 9        | None -----                                                                             | 49.7                            | ---                  | 18.5                                      | ---                  | 37.9                                       | ---                  |
| 10       | 250 lbs. 16% Acid Phosphate<br>30 lbs. 50% Potash-----                                 | 57.9                            | 5.0                  | 18.3                                      | .6                   | 33.7                                       | -3.5                 |
| 11       | 100 lbs. 15% Nitrate of Soda<br>250 lbs. 16% Acid Phosphate-----<br>30 lbs. 50% Potash | 51.7                            | -4.4                 | 19.9                                      | 3.1                  | 41.1                                       | 4.7                  |
| 12       | 250 lbs. 16% Acid Phosphate<br>10 Tons Well Rotted Manure-----                         | 55.1                            | -4.2                 | 24.0                                      | 8.1                  | 36.1                                       | .4                   |
| 13       | None -----                                                                             | 62.4                            | ---                  | 15.1                                      | ---                  | 35.0                                       | ---                  |
| 14       | 200 lbs. 15% Nitrate of Soda<br>500 lbs. 16% Acid Phosphate-----<br>60 lbs. 50% Potash | 56.1                            | -3.6                 | 31.7                                      | 12.8                 | 34.1                                       | -9                   |
| 15       | 100 lbs. 15% Nitrate of Soda<br>applied on 15 inch plants-----                         | 57.9                            | .8                   | 24.6                                      | 1.9                  | ---                                        | ---                  |
| 16       | -----                                                                                  | ---                             | ---                  | ---                                       | ---                  | ---                                        | ---                  |
| 17       | None -----                                                                             | 54.4                            | ---                  | 26.6                                      | ---                  | ---                                        | ---                  |

The test with corn located on the farm of Mr. Jobe Phillips, Cleburne County, was on Hanceville loam. All of the treatments gave some increase, manure used alone giving the largest increase, of 13 bushels per acre. None of the fertilizers paid for the cost of application with the exception of nitrate of soda and acid phosphate used alone, and the increases produced by these treatments only slightly more than paid for the cost of the application.

The test with corn on the farm of Mr. G. M. Cravens, Logan County, was located on Hanceville fine sandy loam. The largest increase due to fertilizer was from the use of the heavy application of complete fertilizer, the second largest being produced by the use of nitrate of soda and acid phosphate. None of the fer-

tilizers gave a profitable increase on the basis of prices prevailing during this season.

The test on the farm of Mr. R. D. Blazer, Pulaski County, was located on Hanceville loam. All of the fertilizer treatments gave some increase, the heavy application of complete fertilizer giving the largest increase. None of the fertilizers gave increases sufficiently large to pay for the use of the fertilizer.

The test carried out by the Temtor Products Company, with sweet sorghum, was located on silt loam valley land near South Fort Smith. Considerable increases were obtained, the largest increase being obtained by the use of manure reinforced with acid phosphate. The benefit derived from acid phosphate used alone, and in combination with nitrate of soda, or potash, is outstanding.

The test on the Burdette Plantation, Mississippi County, was located on Sharkey clay. Little advantage, and in some cases a reduction in yield was produced where fertilizers were used. This test also shows that little benefit can be derived from the use of commercial fertilizers on corn, on the richer lands of the Delta section that have been under cultivation only a short time.

The test with corn on the farm of Therold Bailey, Cross County, was located on the fine sandy loam typical of the Delta section. All of the fertilizer treatments gave some increase, manure giving the largest increase, followed by the heavy application of complete fertilizer. None of the treatments with commercial fertilizer, however, were sufficiently large to pay for the fertilizers used.

The test on the farm of Mr. J. M. Hewitt, Lee County, was located on Lintonia fine sandy loam. No advantage, and in fact a reduction of yield was obtained on many of the fertilized plats. This particular test did not receive a rain from the time it was planted until it was harvested. Under such conditions the use of fertilizer may increase the early growth of corn and make it more incapable of withstanding a drouth than unfertilized corn. The test shows that under certain climatic conditions practically no benefit can be derived from fertilizers.

### CONCLUSIONS

The ready response of crops to applications of manure is clearly shown. Manure is not only a complete fertilizer carrying all plant foods, but is also a carrier of organic matter, which helps the soil to retain moisture during the drier portions of the season. In almost all cases manure gave a large increase of both corn and cotton, many times doubling the yield over the "no treatments." Usually the use of acid phosphate, used along with manure, gave a still larger increase than the manure alone.

The tests show a widespread need of nitrogenous fertilizers, as a ready response to the use of nitrogen as a fertilizer is shown,

not only when applied in manure but in commercial fertilizers as well. The increase of available nitrogen almost always results in an increased yield, but the yields are not always profitable.

Phosphorus can be counted on as the plant food purchased in commercial fertilizers that will be most sure to give a profitable return on the money invested. Under normal conditions phosphorus carrying materials should make up the bulk of the fertilizers used.

There is likely to be a rather limited amount of available potassium in the sandier soils, and it is well to use potash in the fertilization of crops on these sandier soils.

The results indicate that it is much more profitable to use commercial fertilizers on cotton than on corn. While corn may make a substantial increase where fertilizer is used, still the value of the increase is very frequently not sufficiently large to pay for the fertilizer used. With cotton, which is a relatively high money value crop per acre, only a small increase in yield is necessary to pay for the fertilizer, and a substantial increase in yield will almost always mean a considerable profit. One can, therefore, afford to use larger amounts of fertilizer on cotton than on corn, and for this same reason one can afford to use large amounts of fertilizers on truck crops and other high acre value crops.

In the cotton growing sections it will be well to plan on using most of the commercial fertilizer purchased on cotton, with the exception of the use of highly phosphate fertilizers on legume crops, and to depend on farm produced material to a large extent in the fertilization of corn. The character of the cotton crop seems to make it better adapted for making the best use of the commercial fertilizer.

On the sandier upland, in the Coastal Plains section, the use of a complete fertilizer will usually give best returns. A fertilizer carrying 8% to 10% phosphoric acid, 2% to 4% nitrogen, and 2% to 4% potash may be used for cotton, applying it at the rate of from 300 to 500 pounds per acre. Where the soil is fairly well supplied with organic matter and capable of holding a fair amount of moisture, a larger amount of commercial fertilizer can be more safely used than where the soil is inclined to be drouthy.

The soils of the hill section generally give their largest increase from an application of a complete fertilizer, although many times the increase produced by a fertilizer carrying only nitrogen and phosphorus is almost equally large. On the lighter textured soils in the hill section, that is, those containing a considerable amount of sand, it will be well to use a complete fertilizer on cotton, while on the heavier soils, those carrying more clayey materials, smaller amounts or even no potash may be used.

On the sandier lands a fertilizer analyzing 8% to 10% phos-



phoric acid, 2% to 4% nitrogen, and 2% to 3% potash, at the rate of from 300 to 500 pounds per acre, will give good results. On the heavier lands a fertilizer analyzing 8% to 10% phosphoric acid, 2% to 4% nitrogen, and 0% to 2% potash, used at the rate of from 300 to 500 pounds per acre, under average conditions, will give a good return on the money invested.

The tests clearly show that sorghum will respond readily to the use of acid phosphate and return a good profit on the money invested.

In the fertilization of cotton on Delta lands that have been under cultivation for some time, the use of a fertilizer carrying both phosphorus and nitrogen is recommended. Many of these soils give a good growth of stalk, which indicates a good supply of available nitrogen. Still the production of available nitrogen goes on slowly early in the spring when the soil is wet and cold. The use of a small amount of available nitrogen, such as found in sulfate of ammonia or nitrate of soda, at planting time, along with acid phosphate, gives the cotton plants a quick start. A fertilizer carrying 9% to 12% phosphoric acid and 2% to 4% readily available nitrogen, used at the rate of 400 pounds per acre, under average conditions will give a good return on the money expended for fertilizer. Where the soil is well supplied with organic matter and warms up readily in the spring, acid phosphate used at the rate of 250 pounds per acre will give a profitable increase.

In each of the years for which these tests are reported a number of fertilizer tests were started, from which, for different reasons, no reports were obtained. A large number of these tests were located in the Delta section. In visiting these tests during the growing season it was almost invariably noticed that the early growth was very much more vigorous on the plats receiving complete fertilizer and on the plats receiving nitrate of soda and acid phosphate. This would indicate that for an early start some available nitrogen, as well as phosphoric acid, is desirable.

In some cases, even on these Delta soils which are well supplied with total potash, some available potash may well be used. This is especially true on the sandier lands. It so happens that most of the lands that have been under cultivation for some time are of the sandier nature, because these lighter textured soils were naturally better drained and more readily brought under cultivation.

The amount of fertilizer to use per acre is a question in which there is much interest. Four very important factors to consider in determining the amount of fertilizer to apply are:

1. The crop to be grown.
2. The amount of plant food naturally in the soil.
3. The amount of organic matter in the soil.
4. The water holding power of the soil.

Small amounts of fertilizer usually give the largest returns on the money invested. As the amount of fertilizer is increased a point is finally reached where the increase in the crop produced will not pay for the fertilizer used; that is, so much fertilizer may be applied that the crop can not use all of the plant food supplied.

In these tests a complete fertilizer was applied at the rate of 400 pounds and 800 pounds per acre. The results show that under the conditions prevailing 800 pounds of this fertilizer was too heavy an application for most profitable results. In no case with either corn or sorghum did the increase from the heavy application of the complete fertilizer pay for the fertilizer applied, and out of 21 tests with cotton only 8 of the increases from the heavy application gave a profit above the cost of the fertilizer and most of these profits were not large.

### SUMMARY

Farm manure is one of the best fertilizers. Take care of it. Supplement it with acid phosphate.

Cotton will usually give a much better profit with applications of commercial fertilizer than corn. Plan to use commercial fertilizer on cotton and rely mainly on farm-produced materials in the fertilization of corn.

The upland soils usually give their largest returns when treated with a complete fertilizer. On the heavier soils containing a large amount of clayed material, small amounts or even no potash may be used in the fertilizer.

On Delta soils that have been cropped for years a fertilizer carrying phosphoric acid and some readily available nitrogen should be used. On well drained land well supplied with organic matter, acid phosphate will usually give a good return when used under cotton.

800 pounds per acre of a high-grade commercial fertilizer is too heavy for most profitable returns under average conditions in the state. 300 to 600 pounds per acre will usually give more profitable returns.

Keep up the organic matter content of the soil. Part of the benefit due to applications of manure are the result of the added organic matter.

For a fuller discussion of Soil Management and Fertilization write for Circular No. 97 published by Extension Division, College of Agriculture, Fayetteville, Arkansas.



BULLETIN NO. 181

JUNE 30, 1922

# FARM HELPS FROM EXPERIMENTS



STATE EXPERIMENT STATION FARM, FAYETTEVILLE

ANNUAL REPORT OF THE DIRECTOR

1921-1922

AGRICULTURAL EXPERIMENT STATION

COLLEGE OF AGRICULTURE

UNIVERSITY OF ARKANSAS

FAYETTEVILLE, ARKANSAS

# UNIVERSITY OF ARKANSAS

## AGRICULTURAL EXPERIMENT STATION

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Bradford Knapp, Director of the Experiment Station

Martin Nelson, Vice-Director of Experiment Station

|                               |                                |
|-------------------------------|--------------------------------|
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| J. H. Bux, State Veterinarian | Veterinarian                   |
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| Barnett Sure                  | Assistant Agricultural         |
| J. O. Ware                    | Assistant Agronomist           |

Address all communications to the director. Notify director of changes in address. Bulletins free upon application.

BRADFORD KNAPP, Director.

**UNIVERSITY OF ARKANSAS  
COLLEGE OF AGRICULTURE  
ARKANSAS STATE EXPERIMENT STATION**

**ACCOUNTS**

**RECEIPTS**

**June 1st, 1921, to June 30th, 1922.**

|                                                                                                |                     |
|------------------------------------------------------------------------------------------------|---------------------|
| <b>Received from State taxes through University millage tax-----</b>                           | <b>\$114,645.85</b> |
| <b>Received from Morrill Fund (Federal Treasury)-----</b>                                      | <b>12,388.40</b>    |
| <b>Received from Federal Treasury for Experiment Stations (Hatch<br/>and Adams Funds)-----</b> | <b>30,000.00</b>    |
| <b>Received from sale of products and cash fees-----</b>                                       | <b>11,602.93*</b>   |
| <hr/>                                                                                          |                     |
| <b>Total Funds received for College and Station Work-----</b>                                  | <b>\$168,637.18</b> |

**EXPENDED**

**July 1st, 1921, to June 30th, 1922.**

|                                                                                                  |                     |
|--------------------------------------------------------------------------------------------------|---------------------|
| <b>For College Teaching and all other expenses other than Experi-<br/>ment Station work-----</b> | <b>\$ 79,137.22</b> |
| <b>For all costs of conducting State Experiment Stations-----</b>                                | <b>89,499.96</b>    |
| <hr/>                                                                                            |                     |
|                                                                                                  | <b>\$168,637.18</b> |

**EXPERIMENT STATIONS**

|                                                                                                                |                     |
|----------------------------------------------------------------------------------------------------------------|---------------------|
| <b>For Salaries and staff and regular laborers-----</b>                                                        | <b>\$ 56,404.22</b> |
| <b>For other labor, seeds, equipment chemicals, laboratory supplies<br/>and all items except salaries-----</b> | <b>33,004.74</b>    |
| <hr/>                                                                                                          |                     |
| <b>Total Experiment Station-----</b>                                                                           | <b>\$ 89,499.96</b> |
| <b>This is made up of the following items</b>                                                                  |                     |
| <b>Hatch and Adams Fund from U. S. Treasury-----</b>                                                           | <b>\$ 30,000.00</b> |
| <b>State expenditures of Experiment Station work-----</b>                                                      | <b>56,945.74</b>    |
| <b>From sale of products of farm put back into experiments--</b>                                               | <b>2,554.22</b>     |
| <hr/>                                                                                                          |                     |
| <b>Total-----</b>                                                                                              | <b>\$ 89,499.96</b> |

**\*Of this cash income less than \$600 is in student laboratory fees; the balance is from sale of live stock and other farm products.**

June 26, 1922

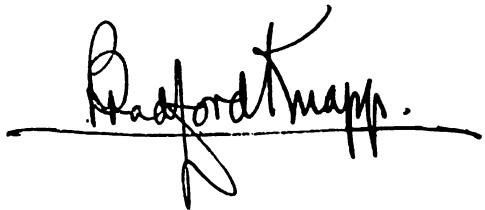
To the Governor of Arkansas  
President of the University of Arkansas  
Board of Trustees of the University of  
Arkansas, and The State Board of Con-  
trol of Experiment Stations.

Gentlemen:

It is provided under the terms of the Hatch Act, creating the State Experiment Stations, that an annual report shall be made to the Governor of the State, copies of which must be sent to other Experiment Stations. An annual report should also be made to the President of the University, Board of Trustees, and especially to the Board of Control of State Experiment Stations.

I take pleasure, therefore, in transmitting herewith the annual report of the Arkansas State Experiment Station, which is a part of the College of Agriculture of the University of Arkansas, for the fiscal year ending June 30, 1921, and also for the fiscal year ending June 30, 1922.

Respectfully submitted,

A handwritten signature in dark ink, reading "Radford Knapp". The signature is written in a cursive style with a large, sweeping "K" and a long horizontal line extending to the right.

Director.

# FARM HELPS

BRADFORD KNAPP

## FOREWORD

Farming has not passed through such a severe period of depression, as that of 1920-'21, since the period immediately following the Civil War. The tremendous slump in prices of farm products came upon our people almost unawares. From the pinnacle of high prices farmers were precipitated into a period of excessively low prices, particularly when the price of farm products is compared with the price of the commodities which the farmer must buy. By the Monthly Labor Review (Volume 14, No. 2), the Index Number of wholesale prices of farm products, using 1913 as 100 per cent, stood at 246 in April 1920. This was slightly below the average of all commodities and was exceeded by the price of food, clothing, building material, and household furnishings. By January 1, 1921 farm products were down to the index figure of 120, compared with 100 for 1913. This index figure is below that of any other class of commodities. By December 1921 this had gone down to 113, and is still much below the average index of the wholesale price of other commodities. How serious this blow was, no one will ever know except those who actually went through the experience itself. Readjustments are taking place now. The product of every such period of readjustment is greater economy, much less of speculation, more caution, a greater degree of thrift, and a more earnest desire to save waste, prevent losses, take every precaution for economy in production, and to systematize marketing.

In the National Agricultural Conference held at Washington in January, 1922, a part of the report used these words: "The farmer can help himself by proper diversification of crop and live stock enterprise, by adjusting farm operations to market demands, by the use of improved varieties of crops and pure-bred live stock, by producing a larger part of the family living on the farm, by effecting reductions in the cost of farm operations, by the elimination of unnecessary expenses, and by cooperating with his fellow farmers in the marketing, grading, and standardizing of his crops. If he will do these things, and will keep a record of his business with a view to the elimination of unprofitable enterprises and to the direction of his efforts along more profitable lines, he will be making his full contribution toward the restoration of the agriculture of the country to a permanently profitable basis." The report goes on to indicate that after the farmer has done these things he must ask other agencies to help, among which are named the various government agencies engaged in agricultural work.



In order that agriculture may be profitable in Arkansas, as well as elsewhere, we must be able to compete in efficient production as well as in efficient marketing. A fertile soil, large production per unit of expenditure or cost, superior quality of products marketed, the saving of unnecessary losses, and the use of every means to prevent waste or total loss or injury to farm products, either in the process of production or in the marketing, are items necessary for a permanently successful agriculture. The farmers of Arkansas must compete with the farmers of the other states and of the world. Economy of production and economy of distribution are items of tremendous importance in enabling Arkansas farmers to meet this competition.

The test of efficiency in our agriculture is the standard of living of our people. To maintain a high standard of living and to make farming attractive to worthy young men and young women, there must be an income fairly commensurate with the amount of labor and intelligence put forth.

Every handicap drags our farmers down, whether it be an unknown insect or one for which no control has been worked out, a plant disease or live stock pest, a glutted market, a bad sale, or whatever it may be; even the purchase of farm implements is a matter of knowledge which the ordinary farmer has not the time to gain and with which he cannot afford to experiment.

For thirty-four years past it has been the policy of the federal and state governments to work out the answers to these important problems through the State Experiment Stations. To this, as well as the intelligence of American farmers brought about through the schools, is due the general high standard of American agriculture today. The wonderful resourcefulness shown by the farmers of America during the past ten years is a splendid endorsement of this system and a compliment to the intelligence of the farmers of America in making the results of scientific experiments subservient to their needs.

There never was a time when farmers felt more keenly the need of the work of the Experiment Stations. This need is reflected in the demands being made on the Experiment Stations in every state. In Arkansas the work of the Experiment Station has doubled in a little over two years. Requests from farmers for information are greater than the Station is now able to answer. It is the object of this report to give some idea of lines of work now being pursued.

## WORK OF THE STATE EXPERIMENT STATION

The work of the Experiment Station is divided into eleven departments, as follows:

|                                  |                           |
|----------------------------------|---------------------------|
| Agricultural Chemistry           | Bacteriology              |
| Agricultural Engineering         | Entomology                |
| Agricultural Economics           | Horticulture and Forestry |
| Agronomy and Soils               | Home Economics            |
| Animal Husbandry and<br>Dairying | Plant Pathology           |
|                                  | Veterinary Science        |

Of these all are conducting active experimental work on different problems except the Department of Home Economics. If the Congress of the United States passes the Purnell Bill, now before it for consideration, research work in Home Economics for the benefit of the women of the state will be conducted through this department. Many lines of work need to be taken up in that department.

Besides its laboratories, the work of the Experiment Station is being conducted upon the new main Experiment Station purchased by the Board of Trustees in 1919, consisting of 423 acres of land lying in Washington County, a mile and a half north of the University. Fifty acres of land is being rented at Scott, Arkansas, where the principal variety and breeding work in cotton is being conducted, as well as corn variety and breeding experiments. Important experiments in cotton breeding, testing, etc., are being conducted also in Mississippi County on the Burdett plantation. Large corn variety tests are being conducted in Ashley, Arkansas, and Columbia Counties. Field experiments are under way in forty-one different counties of the state, under the supervision of members of the staff of the State Experiment Station, either in cooperation with farmers, county agents, or schools.

An interesting experiment in the production of purebred beef cattle is being conducted in cooperation with the Bureau of Animal Industry and the First District Agricultural School at Jonesboro.

The accompanying map shows the type and location of the principal outlying experimental work now under way by the Experiment Station.

Some years ago the State had a Rice Experiment Station at Lonoke, conducted on rented land. Misfortune brought a discontinuance of the work of that Station, and practically no work has been done for rice farmers of the state for the past eight years. In view of the importance of the rice industry such an experiment station ought to be located near the center of rice production in Arkansas.

The fruit and truck interests of Southwest Arkansas also need a greater amount of attention. The work of the Experiment Station would be greatly facilitated by the addition of a reasonable amount of land for a branch station for cotton, rice, and fruit and truck crops respectively.



average farms contains seventy-five acres. The State Department of Agriculture reports the value of farm products in Arkansas for the year 1920 to be \$346,228,500.00 and for the year 1921, \$200,814,460.00. The valuation of all property of the state for the purpose of taxation is about \$600,000,000.00.

Therefore for the season of 1921-22 the cost was less than one-tenth of a mill on the assessed valuation of all property, or about twenty-five cents per farm, or about one-fourth of a mill on each dollar of the 1921 agricultural production of the state. Less than one pound of butter fat, a dozen eggs, five pounds of peanuts, one peck of Irish potatoes, a third of one bushel of corn, a little over one-fifth of a bushel of wheat, a little more than one quart of syrup, or one and a quarter pounds of cotton per farm would pay the bill.

The results of the experimental work of the State Experiment Station, when finished, are published in bulletins which may be had upon application. A list of bulletins recently published is appended as a part of this report. The following pages contain brief mention of the more important practical results of the past year. There is also appended a full list of all projects now under way, and a financial statement of funds expended in the Experiment Station work.

The statements do not attempt to give all of the results or outline all of the work under way. Work not ready to report is withheld. This report omits the technical scientific matters, and attempts to give results in a form which may be understood by all.

## LABOR REQUIREMENTS OF ARKANSAS CROPS

How to plan the work of the farm has always been regarded as a matter of importance, and it is one in which the good manager excels. We have heretofore lacked, however, some of the fundamental data or information needed for proper planning. We need to know about how much work is involved on each crop in each month so that conflicts between crops may be avoided or, at least, minimized. We need also to know what secondary or supplemental crops fit best with the main crop. We also ought to know the total quantity of labor, both man and horse, to assist in studies on the cost of production.

Prof. A. D. McNair of the Department of Agricultural economics in cooperation with the United States Department of Agriculture has been engaged in farm management investigations. During the past year the work of mapping or charting the work on Arkansas crops has been completed from a study of the work of hundreds of farms. There are 51 charts altogether, and these show the number of days of labor on each crop for each month. Not only are the days of man labor shown but the horse labor also.

There are five charts for cotton for five different parts of the state, eight charts for corn, two for wheat, two for oats, two for cantaloupes, two for watermelons, two for sweet potatoes, two for cow pea hay, early and late, and one for most of the other crops. For strawberries and blackberries there is a chart for first year berries and another for stawberies and blackberries in bearing. The charts for the labor on apples, pears, cherries, peaches and grapes are for orchards and vineyards in full bearing.

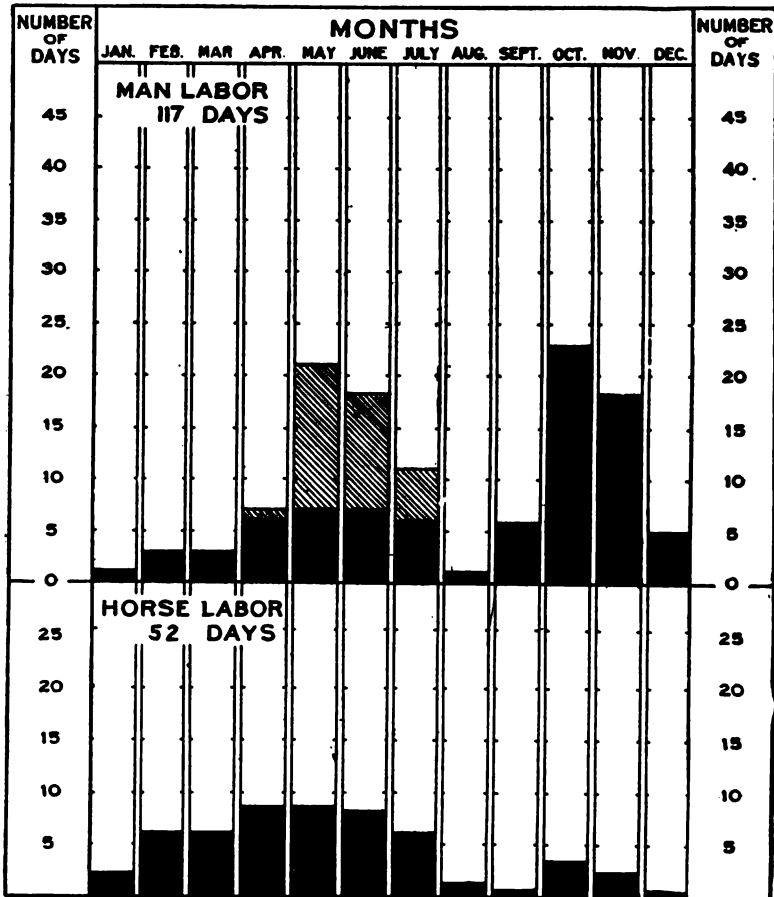


Figure 2. Labor requirements on ten acres cotton in Chicot County.

Two of the charts are presented herewith to illustrate the nature of all of them. The first one shows the average labor on 10 acres of cotton in Chicot county in the region of large planta-

tions. The labor of picking is based on a yield of 600 pounds of seed cotton per acre, hence would be greater or less than shown if the yield were greater or less. The shaded area shows the number of days of hoeing and suggests the need of finding ways to reduce the amount of that work.

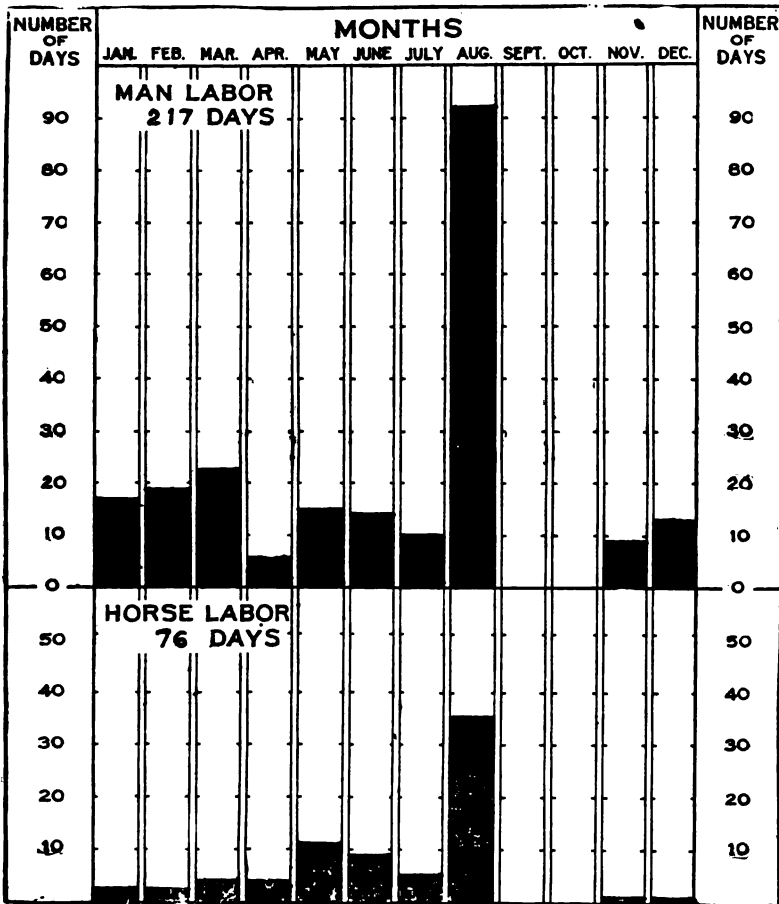


Figure 3. Labor requirements on ten acres grapes, Washington County.

The second chart shows the labor on 10 acres of grapes at Tontitown, Arkansas. The man labor in the late fall, winter and early spring is pruning and tying. The harvest occurs in August, hence the "peak load" of labor on grapes comes when there is practically no work on cotton.

The value of this study is that it shows the fundamental relationships between utilization of labor, utilization of land and

cost of production. It is not primarily a study in the cost of production, but it helps greatly in figuring costs, and seems to point toward a standardized method of figuring costs. The relationship between utilization of labor and of land and of cost of production is made clearer by this study even though detailed cost figures are not given.

In a certain case a two horse farmer spent 150 days a year on productive work and his team spent only 45 days a year on the same. The small number of days that the horses worked resulted in small production and made the cost of horse labor about two dollars per horse per day when it should have been \$1.00 per day or less. The small number of days that he worked resulted in small production, and if we allow him on paper a reasonable yearly wage, it makes the cost per day too high because he did not work enough days. So much for the utilization of labor.

Concerning the utilization of land, his corn yielded only 12½ bushels per acre and his hay one ton per acre. The labor per acre previous to harvest time is nearly the same whether one raises 10 bushels of corn per acre or 40 bushels per acre, hence the labor per bushel of corn or per ton of hay or per bale of cotton is high when the yield is low and it is low when the yield is high. Yields and number of days utilized per year and costs and profits are all related to each other very closely.

The labor data, being given by months for each crop, enables one to plan crop systems that distribute labor throughout the year. The peak load of one crop should, if possible, be made to fit into the idle load of another crop and even though this cannot be done perfectly it can be done approximately with the effect of increasing incomes and reducing costs. The usual experience of bumping up against the problem of a conflict of labor where the crops have peak loads occurring at the same time can be avoided by knowing when the peak loads come and how much they amount to and planning the work accordingly. Even experienced farmers are caught by the conflict of labor between crops the moment they introduce new crops or change the relative proportion of the old ones.

In figuring cost of production the labor data helps to figure it not only for one yield but for all yields because the work before harvest is given separately and the work of harvesting and hauling or marketing is given for a certain standard yield from which it can be estimated for other yields.

A preliminary report of this study is available, and it is hoped to have the complete report at a later date.

## NEW FACTS ABOUT FOOD AND FEED

The science of chemistry is one of the most important sciences to the farmer. Recently chemists all over the United States have been studying problems of nutrition or, in other words, what kinds of feed and the quantities necessary for normal, healthy growth and to enable the animal to bear young and to nourish these young successfully to the point of weaning. Until quite recently it was considered sufficient if human beings and animals were supplied with proper quantities of three general classes of substances. The first of these, known as carbohydrates, includes sugar, the starchy part of grains, and portions of many other substances. The second is fats, consisting of butter fat, lard, animal fats, etc. And the third is known as protein, which is found mainly in lean meats, eggs, milk, and such legumes as beans, peas, peanuts, velvet beans, etc. It has also been known for a long time that the bodies of human beings as well as animals require certain mineral elements such as iron, lime, magnesium, phosphorus and others. These are to be found in many foods, but their importance has not been realized until recently.

Fortunately a good many feeding rations both for man and for animals, planned to contain proper proportions of the above three kinds of substances actually furnished all the requirements for good growth and reproduction. However, chemists began to wonder why seemingly well-balanced rations failed in some instances. They have recently discovered that mere quantity of the three classes of substances is not sufficient. They have found that food substances differ in quality and that the quality of a diet depends upon the chemical character of the proteins in it and also upon the presence of certain substances known as vitamins.

Thus far three different vitamins have been discovered. Chemists call them vitamin A, vitamin B, and vitamin C. If the first is absent the result will be a disease of the eyes, improper bone formation, poor teeth, inability to bear young, and lack of resistance to various infectious diseases. If vitamin B is absent the growth will be poor, the appetite poor, the young cannot be borne and reared with success, and the human or animal system will be unable to resist disease. This lack may also produce other bodily weaknesses and finally result in a paralysis of the nerves and death. Lack of vitamin C results in scurvy and other disorders.

Knowing these things, J. W. Read and Barnett Sure of the Department of Agricultural Chemistry have been studying certain of our most important seeds, produced in Arkansas, to determine what vitamins they contain and what is the real food and feed value as measured by these new requirements. To do



this they have been using small experimental animals (white rats) because they afford the best and most economical means of carrying on the investigations. Scientists have discovered that these animals have practically the same food requirements as have other animals.

In their experiments they have found that cow peas are very rich in vitamin B. Excellent growth, and partial success in reproduction was secured when only twenty per cent of raw cowpeas were used as a source of vitamin B. Cooking the cowpeas proved very destructive to this vitamin. The cow pea contains only a fair amount of vitamin A, and they had to increase the amount to forty per cent in order to keep the rats healthy. The protein in this seed was found to be fair.

The velvet bean has been tested. This seed is rich in vitamin A but very poor in vitamin B. Like other seeds, it is deficient in minerals. In feeding velvet beans these deficiencies must be made up from other sources. The raw velvet bean evidently contains some principle quite toxic to rats. In common language this may possibly be expressed by the word "injurious" or "harmful". This characteristic is removed when the beans are cooked for one hour at fifteen pounds steam pressure. The protein of the velvet bean is not as good for feeding purposes as is that of the cow pea.

They also found that the velvet bean leaf contains vitamin B in abundance and also supplies minerals quite satisfactorily. But the tough seed coats, which have no nutritive value, interfere with the utilization of vitamin A. Satisfactory growth and reproduction through three generations were secured on sixty per cent of the cooked velvet beans, forty per cent of cooked starch, and a liberal supply of whole milk. Forty per cent velvet bean hay, sixty per cent starch, and a liberal supply of skimmed milk brought the same results. On milk alone white rats will grow about one-third normal size, and unless they are fed something in addition to the milk they will stop growth and will fail to reproduce. As a result, velvet beans should not be fed alone, or cow peas alone, to obtain the best growth and strongest and most healthy animals.

### PROTEINS DIFFER IN VALUE

Scientists as well as common people have thought until recently that protein, no matter from what source, had about the same value as a food. Chemists have recently discovered that proteins are composed of different parts, known as amino-acids. Certain of these are particularly required by young animals for growth, and for health and vigor in mature animals. They are no less important than vitamins and minerals. Hence it is im-

portant to know whether common feeding stuffs contain these particular parts of the protein.

Dr. Barnett Sure of the Department of Agricultural Chemistry is studying different proteins from this standpoint. This study is being conducted with actual experiments in feeding small experimental animals as described above.

### DETERMINING SOIL ORGANIC MATTER

J. W. Read of the Department of Agricultural Chemistry has been studying laboratory methods of determining the amount of carbon, nitrogen, and organic matter in the soil. Extensive investigations lead to the conclusion that the methods heretofore used by many chemists have not been entirely accurate. Mr. Read has worked out a new laboratory method and published a bulletin on this subject.

### CAN WE INFLUENCE THE AMOUNT OF OIL IN SEEDS BY THE USE OF MAGNESIUM?

Magnesium is known to have an important part in the nutrition of plants. It exists in practically all soils. Certain investigations in the past have indicated that it has some connection with the formation of oil in very simple plants which do not bear seeds. J. W. Read of the Department of Agricultural Chemistry has been studying the effect of magnesium in the soil on the oil in soy beans and peanuts. In the experiments so far conducted there was a slight increase in the amount of oil where magnesium was added to the soil. Whether this can be made commercially important or not remains for future experiments.

### THE AVAILABILITY OF ROCK PHOSPHATE IN ACID SOIL.

Field experiments carried on in different states have shown that finely ground rock phosphate increases the growth of crops on land deficient in available phosphorus. The phosphorus in rock phosphate is not readily soluble, and the raw rock phosphate is treated with an acid on a commercial scale in the production of acid phosphate, which is more soluble, and therefore a more readily available form of phosphorus.

Since acids tend to make phosphorus available, rock phosphate might be more readily available in an acid soil than in a neutral or alkaline one.

For the last several years, work has been carried on by the Department of Agronomy (Vice Director Nelson and Prof. Sachs) in the greenhouse and in the laboratory, in an endeavor to determine the availability of rock phosphate in acid soils. Crops have been grown on acid soils under different treatments with rock phosphate. The crops have been harvested and analyzed to find out how much phosphorus crops have been able to pick up from

the soil. The soils have been sampled after each crop and the readily soluble phosphorus determined.

The results indicate that corn can use phosphorus added to an acid soil in the form of finely ground rock phosphate. There is an increase in the percentage of phosphorus in the corn plant, as well as an increase in the total amount of phosphorus in the crop. Where an acid soil is treated with finely ground rock phosphate the addition of lime appears to decrease the amount of phosphorus available for the corn plant when grown on acid soil.

### REQUIREMENTS IN ALFALFA PRODUCTION

Where alfalfa can be grown successfully it is, all things considered, the most desirable forage crop that can be grown. Conditions necessary for success in the production of alfalfa are points which the Experiment Station is studying with much care through yearly experiments conducted by the Department of Agronomy. From these investigations it is apparent that among the conditions to be provided for alfalfa are:



Figure 4. Excellent crop of Alfalfa growing on Station Farm.

1. Good drainage.
2. Land free from weeds.
3. A state of fertility that permits reasonable growth of crops.
4. Inoculation.
5. A soil that is not decidedly acid or sour.

It is recommended that all of these conditions be provided on land where alfalfa is to be grown for the first time. Frequently one of the five factors named, when overlooked, is re-



Figure 5. Making Alfalfa Hay, Experiment Station Farm. New mown hay in foreground. Covered shocks in background.

sponsible for failure and discouragement. To eliminate weeds a two or three year plan of cropping the land with a view of destroying the weeds previous to seeding alfalfa is highly desirable, and the crop is well worth this trouble. The fertilization should consist of the application of manure reinforced by acid phosphate, or the use of commercial fertilizers in connection with green manure crops. Inoculation may be provided by using soil from another alfalfa field, from a field of bur clover, from a field of sweet clover, or by using artificial cultures. Crushed limestone, where available, is suitable to use to the extent of one or two tons per acre, depending upon the degree of acidity. Deep plowing should form a part of the preparation for alfalfa, and might well begin several years before the crop is to be seeded. It is best to seed without a nurse crop. Fall seeding is best when moisture is at hand to produce prompt germination, otherwise, seeding in early spring is better. A crop of alfalfa is sufficiently valuable to justify beginning this crop on the best piece of land found on the farm. Its requirements are definite and exacting. When they are supplied the crop's returns are very gratifying.

### ROTATION AND FERTILIZER WORK.

The first season's results from fertilizers on the new Experiment Station Farm at Fayetteville were obtained during the season of 1921. (Vice Director Nelson, Prof. Sachs, Mr. Austin)

The results show the ready response of small grains to applications of nitrogenous fertilizers. The application of 3 tons of manure increased the yield of wheat two-thirds, and the addition of 250 pounds of acid phosphate to this amount of manure more than doubled the yield. Oats gave a good response to small applications of nitrate of soda.

The effect of a 3-ton application of manure on the stand of clover obtained where the manure was applied to fall seeded wheat and clover seeded in the wheat in the spring, was striking. (See Fig. 6). Where no manure was applied there was almost no

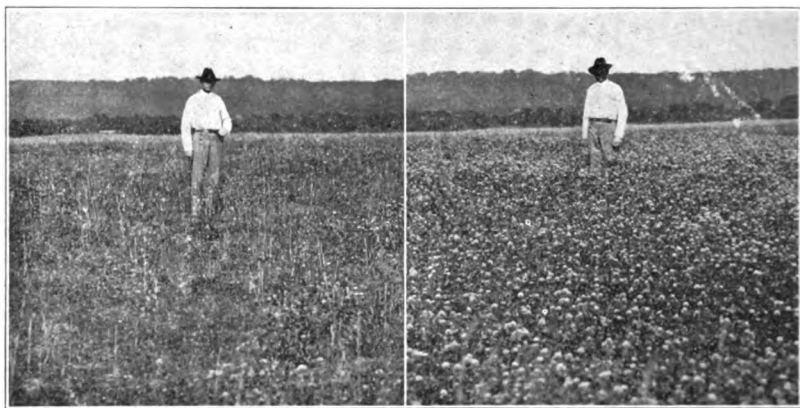


Figure 6. Clover following wheat. No treatment on left. Three tons manure per acre applied to wheat on right.

clover, while where manure was applied the stand was good. The yield of clover hay at the first cutting was approximately a ton more where manure had been used than where no manure was applied. Where acid phosphate was used at the rate of 250 pounds per acre along with the manure the yield was  $1\frac{1}{2}$  tons more than where no treatment was used. This light application of manure made the difference between a practical failure of clover and a good crop.

On another field the use of acid phosphate at the rate of 250 pounds per acre increased the yield of clover from 3620 pounds to 6270 pounds per acre, an increase of over 2600 pounds per acre. The hay obtained where fertilized was of a better quality, as there was more grass and weeds in the hay from the unfertilized land.

### COOPERATIVE FERTILIZER EXPERIMENTS

Cooperative fertilizer experiments have been carried on at different points in the state for several years by the Department

of Agronomy in their soils work under Vice Director Nelson and Prof. Sachs. The results of the last three years' work are being published as bulletin No. 180.

These experiments have shown that throughout the upland section of the state there is a widespread need of additional nitrogen and phosphorus in the soil. Even in the lowland section, where the soils are naturally better supplied with plant food, the lands that have been under cultivation for years respond to the use of either one or both of these elements.

The results call attention to the great value of manure, for these tests clearly show that manure is one of the best fertilizers. The use of acid phosphate in connection with manure usually gives a still larger increase than where the manure is used alone.

Cotton, because of its high acre value, usually gives a much better profit from applications of commercial fertilizers than does corn. It is a good plan to use commercial fertilizers on the cotton and fertilize the corn with home produced materials.

The results indicate that in the fertilization of cotton on the sandier uplands a complete fertilizer will usually give best returns, while on the Delta lands acid phosphate alone or acid phosphate and some readily available form of nitrogen, such as sulfate of ammonia or nitrate of soda, will usually give largest returns on the money invested.

Medium applications of fertilizer, such as 300 to 600 pounds per acre, will usually prove to be most profitable. Under the conditions prevailing 800 pounds of a high grade commercial fertilizer was shown to be too heavy for most profitable returns.

### NEW SELECTION OF EARLY-MATURING VELVET BEANS

A prolific strain of velvet beans which will mature in Central and Northern Arkansas would be very important for the farmers of those sections. The velvet bean is an important new legume, very desirable for soil improvement as well as feed and forage. The question of maturity in Central and Northern Arkansas is the main problem.

The State Experiment Station, Department of Agronomy (L. W. Osborn) has been making selections with this end in view. Yokahoma, the earliest variety tested, has been found to produce too scanty a growth to be valuable. Best results, from the standpoint of both seed and forage produced, have been obtained from early strains of Speckled Velvet Beans. In 1919 a selection of these beans was obtained from the United States Department of Agriculture. They have been grown on the main Experiment Station farm at Fayetteville for two years, and each year careful selections have been made. They have been grown one year at the Experiment Station at Scott. In the tests at Fayetteville they have matured seed well ahead of frost each year. Over fif-

teen bushels of the seed of these selections have been produced and distributed by the Experiment Station to farmers over the state for testing under varying conditions this year. Selections for early maturity will be continued upon the Experiment Station. Osceola Velvet Beans have proved a very desirable variety for Central and Southern sections. This variety produces seed abundantly in the southern part of the state, but does not mature in the northern part. Chinese and Late Florida Speckled produce no seed even in Southern Arkansas. The Station expects to continue the breeding and selection so that varieties may be developed that will mature in all parts of the state.

### **SUDAN GRASS A GOOD HAY CROP**

In the absence of established meadows for hay production, annual hay crops fill a need in Arkansas. The Experiment Station has worked with Sudan grass with promising results. (Department of Agronomy, Profs. Nelson and McClland). Best results are had by seeding shallow with a grain drill, using about 25 pounds of seed per acre. This crop will do well under a wide variety of soil conditions if the land is reasonably well drained. When seed is sown at corn planting time it is not difficult to obtain three cuttings in a season, but the seed may be sown as late as June 1 with prospect of obtaining at least two good cuttings. The hay does not grow as coarse as sorghum. It cures more easily and lends itself readily to handling by the usual hay making machinery. The hay is suitable for general use both for work stock and other live stock. Its feeding value is essentially the same and fills the same place as good grades of other grass hay such as timothy, orchard grass, and Bermuda hay. Yields are much better than can be obtained from most other crops, and



Figure 7. Sudan grass. An excellent hay crop, more than 6 feet tall. Experiment Station Farm.

Sudan grass is recommended for general use where an annual hay crop is desired. (Photograph).

### VARIETIES OF COTTON FOR ARKANSAS

"What variety of cotton to grow" has been an open question with the majority of cotton growers. To answer this question the Station has included in its experimental work practically all varieties of cotton that offer any promise for Arkansas. During the past 15 or 20 years varieties and strains of cotton, approaching 200 in number, have been grown in the experiments of the Arkansas Station. (Nelson, Ware, Hodson.) Many of these have been dropped because of lack of merit. New varieties of considerable merit appear from time to time and occasionally prove to be leaders. This fact calls for extensive work over a long period. Certain varieties and strains have consistently yielded high, nine of which are presented in the table below:

| Variety          | Yield per<br>acre 1st<br>picking | Total yield<br>per acre | Per cent<br>Lint | Length of<br>Staple | Money<br>Value of<br>Seed and<br>Lint |
|------------------|----------------------------------|-------------------------|------------------|---------------------|---------------------------------------|
| Deltatype Webber | 149                              | 1459                    | 30               | 1 3/8               | \$171*                                |
| Webber 49-4      | 214                              | 1439                    | 29               | 1 5/16              | 166                                   |
| Express          | 492                              | 1573                    | 28               | 1 3/16              | 144                                   |
| Acala No. 5      | 352                              | 1592                    | 36               | 1 1/16              | 132                                   |
| Cleveland        | 257                              | 1564                    | 35               | 15/16               | 115                                   |
| Triumph          | 198                              | 1432                    | 35               | 1                   | 106                                   |
| Lone Star        | 71                               | 1268                    | 35               | 1 1/16              | 105                                   |
| Rowden           | 90                               | 1334                    | 32               | 1 1/16              | 101                                   |
| Trice            | 498                              | 1435                    | 30               | 15/16               | 93                                    |

\*Note. This is figured on a basis of middling grade with a value representing the average price for that grade and staple at Memphis from July 1, 1921 to Jan. 1, 1922. Seed is figured at \$28 per ton.

To further test the merits of the better varieties, cooperative experiments are conducted with county agents and farmers in different sections of the state, which experiments better enable farmers in these sections to learn to know the leading varieties and to decide for themselves which they prefer to grow.

Along with the cooperative variety testing, standardization of varieties on a gin community basis is urged. This cooperative work furnishes a community with a basis upon which to decide for itself what variety is best for that community. It is just as important that a community limit the varieties grown to one or two, or a few at the most, as it is that good yielding varieties be grown. Under a gin community system based upon one highly bred and selected variety, the farmers can maintain their own seed supply without having to stock up on high priced seed so often. In order to market cotton on the basis of standard grades it is necessary to have a pure stock in a community. It is practically impossible to have pure stock if many varieties are grown and ginned at the same stand.



## ADAPTATION OF COTTON VARIETIES TO DIFFERENT PORTIONS OF THE STATE

The cotton variety which produces the greatest net money returns per acre, one year with another, is the one to choose for any section of the state. Whether this should be a long, medium or short stapled variety will depend upon the locality and premium paid for extra staples. If the gain from an extra price for long staples does not counterbalance the value from larger yields of short cotton, it is best to grow short cotton.

Staple cotton does not thrive so well on hill lands or on any of the rolling lands depleted in fertility. Year in and year out it is economically safe to grow staples only in the bottoms and other alluvial sections of the state.

Soil adaptation and earliness are now the chief factors to consider in choosing a variety. The length of the growing season can no longer be considered, for the annual appearance of the boll weevil limits the fruiting period. Since the weevil comes out earlier farther south, early varieties are necessary everywhere. So far the work of the Station results in the following recommendations.

For all parts of the northern limit of the cotton growing section, the Trice variety is well adapted. It is early and has the ability to thrive on the hill lands, and does not go too much to weed in the cut-over lands in the upper Mississippi Valley.

Triumph is grown a great deal in the hills south of the Trice area and on some of the delta lands where staple is not desired.

Lone Star and Rowden have long been the bender types grown in Arkansas, Lone Star on heavier soils and Rowden on light soils. Both of these varieties do well on the better hill lands south of the Arkansas River and on the bottom lands where the bender type of cotton is desired.

Acala is taking a permanent place through the central and southern portion of Arkansas on the better hill lands and on the lighter bottom lands. It is showing up well.

Express is the standard staple cotton of the state because of its early fruiting character, high yields and ability to thrive on the heavy as well as lighter bottom lands.

In some of the river bottoms and delta regions where staples longer than Express are desired, and the soil is not too extremely heavy, the earlier Webber strains are profitable.

In one or two localities in the state Mead cotton is being tried. It is a variety originally produced by the United States Department of Agriculture to meet conditions in the Sea Island Section of Georgia. The Department of Agronomy is making careful selections of this cotton on the Station at Scott and also cooperating with growers in making selections. Thus far this variety has been somewhat uneven in type and length of lint.

If these defects can be corrected it may prove a very valuable variety with lint longer than other varieties tested.

### **THE EFFECTS OF METHODS OF HARVESTING AND STORING ON COTTON SEED.**

The low germinating power of such a large portion of the cotton seed used for planting often results in unsatisfactory stands. This condition has gradually led to the practice of very lavish use of cotton seed in planting, reaching a point of wastefulness. This condition challenged the attention of our Experiment Station workers several years ago, and research work was undertaken to determine why cotton seed was so generally inferior to other farm seed in strength of germination.

At different stages of the picking season and from fields of cotton exposed to longer and shorter periods of rain and other weather conditions, separate quantities of seed cotton were harvested. These large samples were ginned and the seed stored. In storing, the samples were placed under different conditions and in different amounts.

By using special apparatus, temperatures of the interior of these bulks of cotton seed were taken at regular intervals following storage. Small samples were also taken at different stages and germination tests run on these samples. Parts of these small samples were used for chemical study.

The practical results of this investigation point to the great importance of gathering seed cotton in good condition; that is to say, early, and before it is injured by storms; further that the cotton seed should not be stored in large bulk unless it was harvested in first-class condition. In this investigation seed cotton harvested in good condition, ginned, and the seed stored in small bulk of two or three tons or less, did not deteriorate. However, seed, though harvested in fairly good condition, stored in large bulk, showed a tendency to heat to the point of injury to vitality of seed. Seed cotton gathered when wet or damp led to great deterioration of the stored seed. The seed heated rapidly after storing and reached a point of serious injury to the germinating powers.

Any cotton seed that is not perfectly dry and in prime condition, if to be used for planting, should be spread out in storage so that there is no bulk of any considerable size at any one place where it is stored.

### **COTTON SPACING EXPERIMENTS**

As soon as the boll weevil came to Arkansas cotton growers found themselves face to face with new problems. In an effort to produce cotton profitably under boll weevil conditions spacing experiments were undertaken, and some of the earlier work re-

ported in Station Bulletin 153. It was thought that if conditions could be provided that would reduce vegetative growth in plants and increase early fruiting, it might result in advancing many bolls beyond the state of weevil attack before the infestation of the boll weevil became heavy for the season. Crowding plants in the row tends to bring these results. Some of the earlier work of close spacing of cotton appeared to be significant. In 1921 a more detailed experiment was arranged at the Branch Station at Scott, Arkansas, under the personal direction of Mr. Ware, the results of which are herewith presented in tabulation.

| Plot No. | Spacing     | Way Planted                                         | Plants per Acre | 1st Picking Acre Basis | Total yield per Acre |
|----------|-------------|-----------------------------------------------------|-----------------|------------------------|----------------------|
| 1        | Drill       | Planted in drill and not thinned                    | 25650           | 828                    | 2111                 |
| 2        | Drill       | Planted in drill and thinned 1 plant to 12 inches   | 9625            | 640                    | 1803                 |
| 3        | Hill 6 in.  | Planted in hill 6 in. apart and not thinned         | 17606           | 603                    | 1560                 |
| 4        | Hill 6 in.  | Planted in hill 6 in. apart and thinned to 1 stalk  | 13775           | 612                    | 1425                 |
| 5        | Hill 18 in. | Planted in hill 18 in. apart and not thinned        | 11837           | 575                    | 1482                 |
| 6        | Hill 18 in. | Planted in hill 18 in. apart and thinned to 1 stalk | 7550            | 578                    | 1591                 |
| 7        | Hill 24 in. | Planted in hill 24 in. apart and not thinned        | 7781            | 500                    | 1364                 |
| 8        | Hill 24 in. | Planted in hill 24 in. apart and thinned to 1 stalk | 5268            | 384                    | 1147                 |
| 9        | Hill 29 in. | Planted in hill 29 in. apart and not thinned        | 6062            | 415                    | 1240                 |
| 10       | Hill 29 in. | Planted in hill 29 in. apart and thinned to 1 stalk | 4406            | 400                    | 1234                 |
| 11       | Hill 36 in. | Planted in hill 36 in. apart and not thinned        | 5012            | 406                    | 1305                 |
| 12       | Hill 36 in. | Planted in hill 36 in. apart and thinned to 1 stalk | 3431            | 303                    | 1128                 |

It will be noted that the closer spacing brings, as a rule, earlier cotton. This is shown by the larger weights obtained in

the first picking. Earliness is sufficient to turn the balance decidedly between profit and loss.

As a result of this and similar work elsewhere it is recommended that close spacing be generally adopted in boll weevil sections. A hoe width between plants is practical.

### NEW METHODS OF COTTON PLANTING

Elsewhere in this report we have described the experiment in thicker spacing of cotton under boll weevil conditions and its effect on maturity. Coupled with this a number of the members of the staff of the State Experiment Station have been working upon a somewhat revolutionary method of planting cotton, with the hope of working out plans which would be practical and economical and yet would do the following things:

1. Prevent such diseases as angular leaf spot or boll rot and similar diseases which are carried on the seed coat.
2. Permit the seed to germinate more rapidly.
3. Permit ready sorting of heavy and light seed so that only heavy seed is planted.
4. Make possible the use of machinery which will accurately space the seed.
5. Avoid all cost of chopping.

The Department of Agronomy, under Vice Director Nelson and Professor Ware and others, has been working on the problem of close spacing. Dr. John A. Elliott of the Department of Plant Pathology has been working for the past four years on the problem of control of diseases by delinting the cotton seed. The angular leaf spot, commonly called "rust," is general in its distribution and is the cause of much greater annual loss than is known to most growers. The disease is most conspicuous early in the season as a leaf spot, but in Arkansas it is the cause of at least three-fourths of the boll rot. Very striking results have been obtained by Dr. Elliott during the past four years by the use of sulphuric acid as a control for this disease. Cotton seed is delinted with concentrated sulphuric acid, which process kills all organisms on the outside of the seed. Fields of all sizes up to nearly two hundred acres have been grown almost, if not quite, free from all boll rots, in seasons when the average fields, grown from untreated seed, suffered considerable loss. The process of delinting is simple and relatively inexpensive. Photographs published herewith show steps in acid-delinting. As a result of this work it is apparent that the delinted seed is free from diseases carried on the coat.

During the present season Professor F. A. Wirt of the Department of Agricultural Engineering has been associated in the work in making a study of machinery for fanning out light seed after delinting, and in studying the type of machine and plates

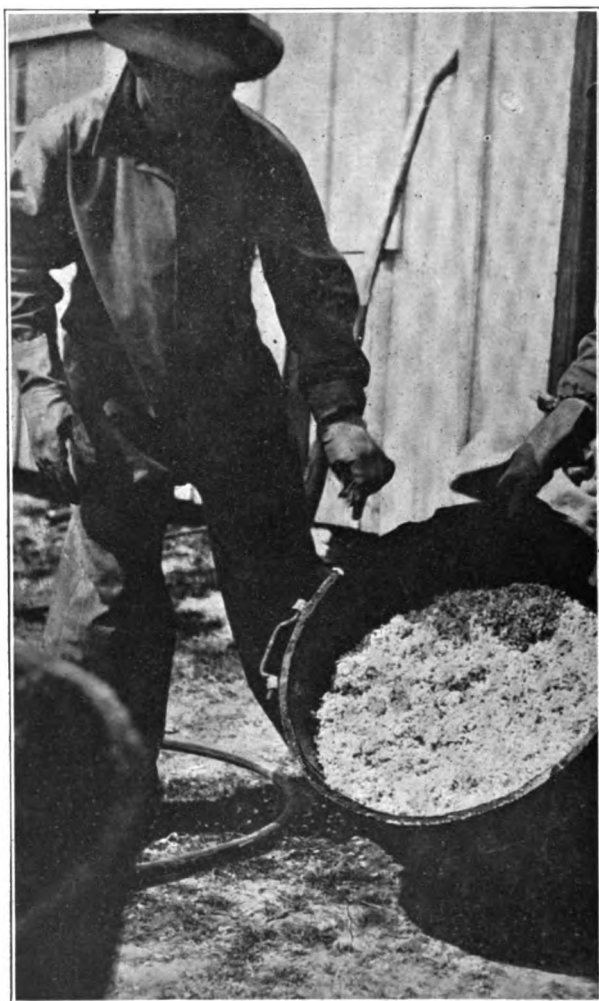


Figure 8. Cotton seed before delinting.

necessary to accurately drop the seed. The use of planters with two revolving plates, to each of which are attached fingers or lugs so as to drop the seed in hills with a spacing of eight to nine inches, are being tested. Plates commonly used for planting cotton seed with the lint on will break or crush delinted seed and cannot be used. On the Experiment Station at Scott this year, in addition to the planting test, the use of a weeder across the

rows, as illustrated in the photograph published herewith, is being carried out.

The object of this experiment can readily be seen. If seed can be spaced accurately from six to twelve inches apart, if



Figure 9. Cotton seed delinted with sulphuric acid.

germination can be rapid and a stand guaranteed by this process, the cost of chopping cotton would be saved and the plants would be practically free from angular leaf spot or boll rot.

However, certain practical difficulties have been met with

and should be mentioned here as a caution against universal adoption of this method until the Experiment Station is able to make further tests:

1. While cotton seed which has been delinted will germinate more quickly under favorable conditions than undelinted seed, in some cases results have not been good, probably due to unfavorable conditions such as too much rain, or too cold weather. The delinted seed germinates quickly under favorable conditions. It may be possible that it also rots quickly under unfavorable conditions.

2. In some instances farmers who have tested this method have failed to get a stand, while in others a perfect stand has been obtained by planting so small an amount as one peck to the acre. One farmer in following this plan in the spring of 1922 used only one peck of delinted seed per acre in an eighty-five acre field, and obtained good results. Sometimes soil forms a crust after planting. Where cotton seed is drilled in the usual manner there is enough germination to enable the seed to break the crust. If the amount of seed is greatly reduced, under some circumstances the seed may not be able to break the crust. This may account for some failures to get a good stand. It is a point which the Experiment Station has yet to test out thoroughly, and is mentioned here as a word of caution.

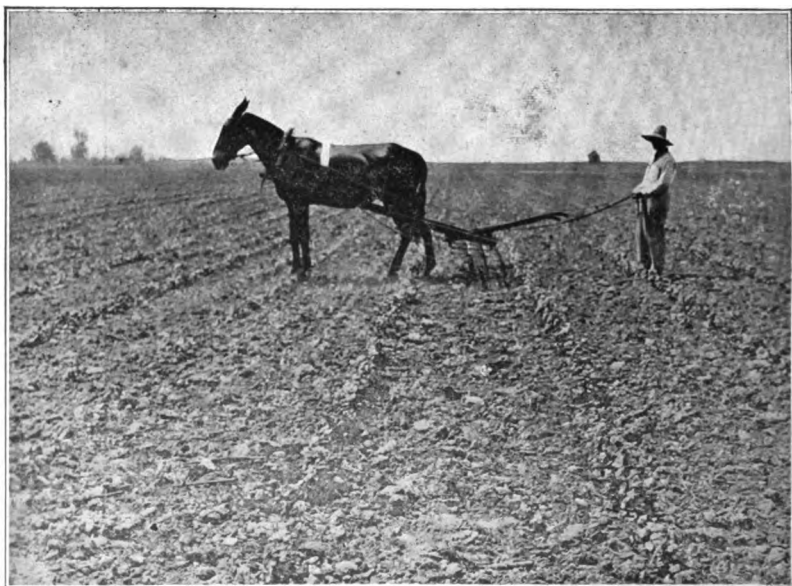


Figure 10. Crossing the rows of cotton with a weeder, destroying weeds before they are deeply rooted.

3. The care necessary in the use of the acid in delinting should be mentioned. It is barely possible that the germinating power of the seed may be injured by careless handling in the process of delinting.

It is perfectly apparent from these experiments that if the Experiment Station is able to work out some of these practical difficulties it may be possible to produce a new method of planting cotton, which will prevent some plant diseases, produce rapid germination, relieve farmers from the cost of chopping, and therefore prove of considerable practical and economical value to the farmers of Arkansas.

### THE SORGHUM CROP

The value of the syrup crop of this state has not been fully appreciated. The relative value of this crop has, in recent years, reached a figure that places it ahead of other crops for which Arkansas has a reputation. In 1920 the value exceeded \$4,800,000. The possibility of syrup production in Arkansas is practically unlimited. The establishment of commercial plants in the state has stimulated interest and given rise to many questions regarding the effect of growing sorghum upon the soil. The Department of Agronomy is working on this problem. (Profs. Nelson, McClelland and Sachs.)

The analysis of the sorghum crop shows, contrary to the general impression, that sorghum does not make a heavy draft upon plant food in the soil. The somewhat unfavorable physical effects of the crop upon soil have given rise to the impression that sorghum injures the land. These bad physical effects are readily overcome by early disking and plowing after harvesting the crop to cut up and turn under the stubble, in order to induce early decay. A simple rotation, following each crop of sorghum by some other crop, will overcome any bad physical effects the sorghum crop has upon the soil.

The Honey variety, or so-called "Japanese Ribbon Cane," is the most popular variety though it is somewhat late. It has given decidedly the largest yields in our experimental work and is the variety most largely used by commercial plants.

Our fertilizer experiments have brought out the fact that acid phosphate is especially effective in increasing yields of sorghum. In every instance where acid phosphate was applied very profitable increases in yields occurred. In several years of experimental work scarcely a single exception is to be found. Manure, and manure reinforced with acid phosphate gave excellent returns. Nitrate of soda or potash used singly did not produce any marked increase in yield of sorghum.



## SEEDING CLOVERS IN SMALL GRAINS

The most ready means at the farmer's command for improving his soil is the use of legumes. It is not uncommon to find fields that have grown oats or wheat lying the balance of the year, and longer, with nothing but weeds growing thereon. If the land has to be plowed after harvest to plant to cowpeas or soy beans, as should be done for the benefit of the soil, it involves much labor in a busy season and the plowing is often next to impossible. If a legume can be sown in the grain it will be very advantageous to the farmer. The Department of Agronomy is working on this problem under Prof. Nelson.

The crops used in this experimental work were Medium and Mammoth Red clover, Lespedeza, Hubam Clover, Spring Vetch, and Cow peas. The vetch and cow peas when cut back in the grain harvest produced very little growth thereafter and so failed in their purpose. A good stand of Hubam clover was had, but the growth did not meet expectations. This is a new crop and probably inoculation was insufficient.



Figure 11. Stand of clover obtained by sowing the seed on thawing surface.

Both kinds of red clover and lespedeza were generally successful, on both fall and spring sown grain. In the case of winter grain, both wheat and oats, seeding clover on a late snow gave the seed lodging in the soil, and the stand was good. Seeding clover on a thawing surface brought good stands. When these conditions do not obtain, cultivation to give the seed lodging is necessary. A single harrowing before seeding was sufficient where the soil was loose. Harrowing before and after seeding was necessary where the soil was packed.

Lespedeza sown on the surface of winter seeded grain without harrowing was a marked success.

On spring seeded grain red clover sown after the grain drill without harrowing was a success. Harrowing the loose soil covered the seed too deep.

Lespedeza was a success sown without harrowing, but failed when sown and harrowed following the grain drill.

Clover seeded in the fall on fall sown grain did not have time to get a start though it might result in a stand in very exceptional seasons.

### BUR CLOVER PROMISING

Bur clover is one of the most promising of our winter legumes. Its habit of reseeding itself and of the crop "volunteering" again after two or three years makes it important both for soil improvement and as an economical problem in farm management as all cost of preparation of soil and seeding is saved. The Departments of Agronomy under Profs. Nelson and McClelland and Agricultural Economics under Prof. McNair are working on this problem.

Bur clover sown on small grain is not a success, due to its habits of growth. It starts normally in the fall before any small grain should be sown. It matures just ahead of or nearly at the same time as the small grain crop. Consequently the two crops attempt to come to their best about the same time, and the competition is too great. Then, too, summer months must pass without a crop on the land.

In connection with cotton and corn crops, bur clover works in well and promises to be one of the most useful legumes in Arkansas agriculture. Both cotton and corn permit a volunteer stand of bur clover to be safely established in the fall. A crop of corn can be grown after the seed crop of bur clover has matured in May or early June. Crops of corn and sorghum for silage can easily be produced after bur clover has matured.

The volunteering habits of bur clover are unusual. A seed crop plowed under produced good volunteer stands in cotton for three successive falls without seed maturing in the meantime, as cotton was grown each year. This characteristic makes it possible to use bur clover with a variety of crops and rotations.



Figure 12. Good corn crop following seed crop of bur clover.



Figure 13. Sorghum following a seed crop of bur clover

### AN IMPROVED STRAIN OF RYE FOR ARKANSAS

The climatic conditions of Arkansas create a most serious need for cover crops to conserve the soil. A cover crop will accomplish several things. It prevents erosion; it holds plant food against leaching, which is probably the greatest source of loss in Arkansas agricultur; it serves as a pasture crop; it supplies

vegetable matter to return to the soil. Rye is one of the best cover crops, especially on rolling land. It is also one of the best for winter pasture. Both the work of the Station and the experience of farmers have shown the need of rye better adapted to Arkansas conditions. A need has been felt for rye more hardy, of more vigorous growth, and of better seed yielding qualities than obtains with the majority of rye grown in the state.



Figure 14. New selection known as "Station Rye," almost 6 feet tall, dense and well headed.

The Experiment Station has produced an improved strain of rye which, for the northern part of Arkansas at least, is fully equal if not superior to Abruzzes because of its greater frost resistance. This new strain of rye is grown at present under the name "Station Rye." It has been tried to a point where distribution of this more suitable strain of rye will be made among farmers of North Arkansas as rapidly as the stock of seed can be supplied. Whether it will prove as good as Abruzzes for Central and Southern Arkansas cannot be stated until further trial and selection.

#### FACTORS AFFECTING PRODUCTION OF WINTER OATS

There are several advantages in growing winter oats in preference to spring oats, where they can be grown successfully. As a general rule the establishing of a crop in the fall, so that it has a substantial root system to begin with when growing weather arrives in spring, gives it a decided advantage over a crop that must start from seed in the spring. Winter oats, therefore, have better opportunity to complete growth and produce satisfactory

yield than do spring oats. Another advantage in growing winter oats is that it supplies a cover crop to protect the soil during winter months. There is still another advantage, namely, that where the crop is seeded in the fall that much work is done, leaving more time for planting other crops in the spring.

Whether a farmer will grow winter oats or spring oats will depend on his success in getting a stand of oats through the winter. It is plain that he should start with seed grown as winter oats, so that the stock of seed may be hardy. Nevertheless, there is occasional loss from winter killing. Investigation by the Experiment Station has been directed toward reducing this loss. Several factors enter in. One of the most important is the time of seeding of oats in the fall. It was found in our work that seeding in ample season, but not too early, would bring about a much better start in the fall, and plants with a good root system and a good start would survive the winter where late seeding would fail. Winter oats must be seeded considerably earlier than wheat in any given locality. The period of safe seeding in different sections of the state, as determined by experimental work, is as follows:

In the Ozark section and Northeast Arkansas, from September 10 to October 10.

In the West Central section, September, 20 to October 20.

In Southern Arkansas, October 1 to November 1.

These dates in each case cover approximately one month. It is decidedly preferable for the seeding to take place in the first two weeks of the time mentioned in each case, though this will vary materially in different seasons. As a rule, quality as well as yield is better from the earlier seeding.

The method of seeding is a factor in successfully holding the stand through the winter without frost damage. Seeding with a grain drill is altogether preferable to seeding broadcast on the surface. The effect of the open furrow type of drill has been studied as a method of seeding for winter protection. No decided improvement in this method over the use of the ordinary grain drill has been found. Both methods have brought marked improvement over broadcast seeding in escaping winter killing.

The study of effect of dates of seeding has been applied to spring seeded oats as well as winter oats. Far better results, both in yield and quality, are had from reasonably early seeding. It is possible to seed spring oats so early that they may be injured by late freezes. The sooner they can be seeded after the last bad freeze in spring, the better the crop as a rule. Delayed seeding results in a light weight of grain, as well as in decreased yields. Spring seeding must be done within even closer limits than fall seeding. In at least half of the seasons there is usually an advantage if the seeding can be done within a single week.

As a general guide, dates of reasonably safe seeding may be mentioned as follows, for the different parts of the state:

In the Ozark region, and for Northeastern Arkansas, February 25 to March 10.

In West Central Arkansas, February 15 to March 1.

In Southern Arkansas, February 1 to 25.

### THE BETTER VARIETIES OF OATS FOR ARKANSAS

As a result of some years of testing oat varieties the Department of Agronomy has obtained important information for the farmers of the state. Prof. Osborn has been carrying on this work under the general directions of the head of the Department, Prof. Nelson.

Most winter oats for the South can be grouped into two rather distinct classes. One of these is generally known as "Winter Turf." The other class may be grouped under the head of "Rustproof" or "Red Rustproof." There is considerable difference in their habits of growth. There is also a marked difference in their ability to stand winter freezing, in earliness, and in rust resistance. In the north half of Arkansas, where cold waves may be most severe, the Winter Turf and Culberson oats have shown marked superiority in hardiness, and in ability to come through the winter with a full stand. In Central and Southern Arkansas strains of Rustproof, such as Appller, Hastings, Hundred Bushel, Bancroft, and Ferguson 71, have given better yields. For pasture purposes Turf oats are undoubtedly preferable over the state.

As winter oats for Central and Southern Arkansas, the



Figure 15. Developing early, high-yielding strain of oats in the grain nursery.

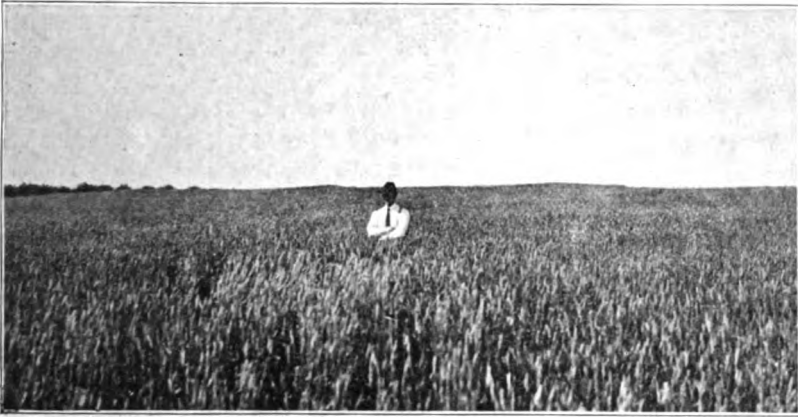


Figure 16. Alabama Blue Stem wheat. One of the best for Arkansas.

Fulghum variety has proved to be very satisfactory. It is an early oat, and may not yield quite as well as Red Rustproof strains, but it is especially suited to rich lands where lodging is likely to occur. Dwarf Culberson has proved a winter resistant, early maturing and high yielding variety, promising in Central and Northern Arkansas, and especially suited to rich land because of its ability to stand up better than other varieties.

For spring seeding, Fulghum oats and strains of Burt oats give better results. Varieties of northern origin should not be considered for grain production, though they may be used for grazing or to cut for hay. They usually grow large, are late, and therefore suffer heavily from rust. The grain is usually light, and in case they lodge can be used for hay only.

### IMPROVED STRAINS

Winter oats suffered heavy winter killing in 1915 and 1917. Selections were made from the surviving stock and pedigreed strains have been developed from these, which apparently possess much merit from the standpoint of winter hardiness and ability to yield. From these and other selections being developed in the grain nursery there are exceptional strains of oats that promise ability to mature early, yield well, and produce grain of good quality. The Experiment Station hopes to bring forth soon some distinctly new types of better oats for Arkansas.

### CORN VARIETIES

Extensive variety experiments have been conducted by the Experiment Station at Fayetteville and other points to determine most suitable types of corn for growing in the state. This work



has been conducted by Vice-Director Nelson and Professor L. W. Osborn. The variety question has been considered important in view of the fact that little attention has been given to seed improvement and, consequently, few varieties have been stabilized over any wide area. An effort has been made to obtain a large number of representative native Arkansas varieties, and the best of these have been grown alongside of the leading varieties which have been obtained from the different cottonbelt and the near cornbelt states. During the present year, this type of investigation is being conducted at the stations at Fayetteville and Scott, and also at Burdette in Northeast Arkansas, and Portland in Southeast Arkansas. Cooperative variety experiments in cooperation with county agents are conducted in a large number of the counties of the state. (See map Fig. 1. showing work in state.)

During the growing season, the different varieties are studied from the standpoint of the time of maturity, height of stalk, ear characteristics, prevalence of suckers, strength and vigor of stalks, prevalence of barren stalks, and disease-resistance. At harvest time, careful notes are taken to determine factors which affect soundness of corn, disease-resistance as shown by ears, size and number of ears, indentation, shelling percentage, and yield.

No variety tested has been found ideal in every respect. Varieties of southern origin practically always produce corn of better quality than varieties of cornbelt origin. Neal's Paymaster, Biggs' Seven-ear, U. S. Selection 201, Commercial White, Hildreth, and Boone County White have proved consistent high yielders in North Arkansas experiments. Prolific varieties, such as Mosby, Marlboro, Hastings, Whatley's, and Cocke's, have been consistent yielders in Central and Southern Arkansas experiments under conditions of abundant moisture. Certain strains of Mexican June, such as Thibault and Surcropper, have proved consistent yielders both at Fayetteville and Scott. Certain acclimatized northern varieties are proving well adapted for uplands because of somewhat earlier maturity, especially Montague's Diamond Joe and Halter's Silvermine.

The abundance of rainfall during the growing season is usually the most important factor in determining the yields of varieties. In a season of abundant rainfall, the medium late or late maturing varieties are practically always either leaders or good yielders in these experiments. Under drouthy conditions, it frequently happens that the tall growing and later maturing varieties are affected by drouth, and that the medium early varieties prove drouth-escaping and make better yields.

### CORN BREEDING

Practically all corn breeding work is conducted in coopera-

tion with the growers of the varieties with which improvement is being attempted. L. W. Osborn is devoting much time to this work. Special attention is being given to the improvement of Neal's Paymaster, Mosby, and Surcrotter, and to two natives, Thibault and McFarland. The varieties are being subjected to careful selection to improve both stalk and ear characteristics.

Hybridizing varieties to determine the yield from first generation crosses showed material increases from certain combinations of varieties. Combinations which gave consistent increases over the parents were Mosby X Hildreth, and Surcrotter X Hildreth. A cross between Hastings' Prolific, a late maturing prolific variety, and Funk's Ninetyday, an early maturing Illinois variety, resulted in progeny appearing quite intermediate in growth and in time of maturity, with the yield of the cross equal to the yield of the prolific parent and much larger than that of the early variety.

### RATES OF PLANTING CORN

Experiments are conducted each year at Fayetteville and at Scott in which several varieties differing in growth characteristics and time of maturity are compared in varying rates of planting. The rate of planting of a variety for best yield is found to vary with the soil and season. Planted on good soil, in four-foot rows, varieties with a long growing season, like Mosby and Hastings, will produce best, in a wet season, with 18-inch spacing, and in a dry season with 36-inch spacing. Medium early varieties, such as Reid's Yellow Dent and Silvermine, gave best results with a 12-inch spacing in a favorable season, and a 24 or 30-inch spacing in a dry season.

In view of the frequency of summer drouths during July and August, it seems best to give corn liberal spacing in order to make a fair yield each year, rather than to try to make a big yield of corn by closer planting and assume the risk of drouth. Corn growing should be accompanied with soil-improvement practices which will increase the humus in the soil. If this is done, the moisture-holding capacity of the soil is increased and closer planting is then practicable. Unquestionably higher yields are obtained in favorable years from the closer plantings.

### TIME OF PLANTING EXPERIMENT

Experiments have been conducted at Fayetteville and Scott in which several varieties, differing in time of maturity, are being compared from the standpoint of time of planting. The different plantings are made the first and middle of each month, beginning with April 1, and ending July 15.

Plots of the same variety planted at different dates frequently show tremendous variation in vigor, size of stalk, and other growth characteristics because of difference in rainfall affecting

different plantings. Early plantings require a longer period of maturity than later plantings. In 1920, the plantings made on a certain date all lodged and fell to the ground, apparently because of weak stalks. Usually best yields and most growth is obtained from the earlier plantings.

### CHECK VERSUS DRILL PLANTING OF CORN

Experiments conducted comparing check and drill methods of planting corn, so far, indicate little difference, if any, in favor of either method of planting. Usually, the advantage tends to be in favor of uniform spacing in the same row. The use of a check-row planter is justified under conditions where it may be used in order to reduce the expense of hoe-labor by cross-cultivation.

### METHODS OF CULTIVATION OF CORN

The importance of good cultivation cannot be overestimated. The problem of cultivation is being studied from the standpoint of (1) proper depth of cultivation; (2) effect of delayed cultivation in spring; (3) time of laying-by; (4) effect of laying-by deep. The results of the experiments to date indicate the outstanding importance of eliminating the weeds as the biggest reason for cultivation. Presence of weeds in corn causes a greater reduction in yield than any variation in the method of cultivation. Plots which are scraped, but not cultivated, and plots receiving very shallow cultivation, about one inch, generally yield somewhat below plots receiving cultivation to a medium depth, three to four inches. It has been observed that plots receiving very shallow cultivation, or which are scraped, lodge or blow down to a greater extent than where the depth of cultivation is increased. Real deep continuous cultivation, five to six inches, has, likewise, resulted in a decrease in yield. Practically no difference in yield has resulted from the laying-by of corn at the waist-high stage as compared with later stages, excepting in seasons when weeds became abundant in the plots laid-by early. Laying-by corn when waist-high, or even earlier, is undoubtedly practical when weeds are not likely to grow rapidly; however, since this is not usually the case, it is often better to continue cultivation until after the tasselling period.

To hold moisture, destroy weeds and assist in making plant food available, it is evident from these experiments that if the farmer "cultivates shallow" it must not be too shallow. Where land is well prepared not less than three inches of the surface should be cultivated even in "shallow cultivation." It is evident also that continuous, very deep cultivation decreases yield and does not pay.

## WIDE AND NARROW ROW PLANTING OF CORN

Experiments have been conducted, both at Fayetteville and Scott, comparing corn planted in rows 4, 6, and 8 feet wide, with cowpeas drilled in a single row through the center of the 6 and 8-foot rows. The results indicate that approximately 80-85 per cent of a full yield of corn may be obtained when corn is planted in 6-foot rows, and 60-75 per cent, when corn is planted in 8-foot rows. The practice of planting corn in 6-foot rows with a legume drilled through the center is very desirable, and especially on soils lacking in humus, where soil-improvement practices should be adopted.

## LEGUMES IN CORN

What is the effect of planting legumes in the corn row? To answer this question, the Experiment Station is conducting experiments in which cowpeas, soy beans, and velvet beans are planted in the corn row at time of planting, when the corn is 6 inches, 12 inches, 24 inches, and 3½ feet high. In the experiments so far conducted, the legumes reduced the yield of the corn greatest when planted while the corn is young. The yield of corn is not reduced materially when the legume is planted at the 3½-foot stage. Velvet beans have decreased the yield of corn to a greater extent than cowpeas or soy beans.

## SEED DISTRIBUTION

The Experiment Station cooperates with the membership of the Arkansas Seed Growers' Association, from time to time, in the distribution of improved strains of varieties which have been determined at the Experiment Station farm. In some instances, the seed is sent in small quantities to the entire list of co-operators; in other instances, the seed-stock is divided between two or three farmers for multiplication. Varieties which are being multiplied in this way are Fulghum oats, Dwarf Culberson oats, Alabama Bluestem wheat, Neal's Paymaster corn, Biggs' Seven-ear corn, and an extra early strain of Speckled velvet beans. One-pound samples of Hubam clover and of the velvet beans were distributed generally to all members. Prof. Osborn is secretary of the Seed Growers' Association which closely associates the work of the growers with the work of the Experiment Station.

## EFFECT OF CULTIVATION DURING THE GROWING SEASON ON MOISTURE CONTENT AND FORMATION OF NITRATES IN THE SOIL.

Determinations of moisture and nitrates were made from time to time throughout the season of 1921, by Professor Sachs and Mr. Austin of the Agronomy Department, in connection with

the regular cultivation experiment with corn, in order to find what influence different methods of cultivation have on the amount of moisture retained in the soil, and the amount of available nitrogen produced.

The crop is constantly using both water and nitrates. Determinations were made on cropped and uncropped soil receiving the same kinds of cultivation, in order to get an idea of the total amount of moisture and nitrates available for the crop.

The results show the heavy drain of weeds on the supply of both moisture and nitrates. On July 20, when growth was rapid, the uncropped plot, where seeds were allowed to grow, contained only two pounds of nitrate nitrogen in the surface soil of an acre, as compared with over 100 pounds on some of the non-cropped plots that were kept free of weeds. About  $1\frac{1}{2}$  pounds of nitrogen are required to produce a bushel of corn. On the plots where weeds were allowed to grow there was only enough available nitrogen to produce a little over a bushel of corn, while on some of the other plots there was sufficient nitrogen available to produce 65 bushels of corn.

Weeds also draw heavily on the water supply in the soil, the seasonal average moisture content on the plots where weeds were allowed to grow being the lowest moisture content found.

Deep cultivation gave the highest seasonal average of nitrates in the soil. The nitrate content indicated that at least on this soil the deeper it is stirred the more available nitrogen will be produced. Of course no cultivation should be continued long which actually cuts the roots and therefore decreases the feeding area of the plant.

Nitrates produced, if not used by a crop, are very likely to be lost by leaching. The action of any crop, even a crop of weeds, in taking up and using soluble nitrogen as it is produced in the soil indicates the value of a cover crop which can utilize the soluble nitrogen in its growth, and later release it for a following crop after the cover crop decays in the soil.

### SOY BEAN CULTURE

Legumes should have a large place in Arkansas agriculture. Where a crop has many advantages in addition to being a legume, it ought to be considered on its merits. Soy beans possess the several merits of being a good hay crop, a good crop for pasture and forage purposes, a cash crop with large possibilities, and a producer of vegetable oil. The price of soy bean seed continues as a rule at a level that makes farmers hesitate to buy. They ought to consider seriously the advantage of having seed to sell. Varieties that are good yielders of seed must be grown for this purpose. From among 60 or more varieties grown by the Experiment Station, Mammoth Yellow, Tar Heel Black,

Shanghai, Virginia, and some others stand out as good yielders of seed.

In the growing of soy beans for oil production the yellow seeded varieties are preferable because of the clear color imparted to the product. Mammoth Yellow is especially suitable; also Hollybrook, so far as color of seed is concerned. The demand for clear, pure vegetable oil for use in paints, varnishes, soaps, culinary and other purposes, will continue to grow with the population. It has been thoroughly demonstrated that soy beans can meet these demands fully.

For forage and hay production the fine stemmed varieties are preferable for reasons that are obvious. Such varieties as Chiquita, Virginia, Arlington, and Ootootan are excellent. The Biloxi variety has proved to be especially adapted to Southern Arkansas because of its non-shattering habits.

Soy beans are being recognized as an excellent forage crop for hogs. For this purpose a fair yield of forage and a good yield of seed is desired, together with reasonable earliness. Virginia, Wilson, Ootootan, and Arlington are among the varieties that meet this requirement best.

### SOIL SURVEY WORK

For some years past the Department of Agronomy, under the leadership of Vice-Director Nelson, has been collecting the necessary data for publishing a general soil map of the state. This map when published will show the general character of the soil in different sections of the state, with a description of soil types found in different large soil areas. These descriptions will give not only the physical characteristics of the soil but also the average amount of total nitrogen and phosphorus found in these types, together with their need or lack of need of lime, and will indicate methods of improvement. This will be a general report on which work is now finished but publication not made because of lack of funds. It covers the whole state, and is a result of years of patient work. Much of this material was collected without additional expense by various workers of the Experiment Station.

The Bureau of Soils of the United States Department of Agriculture has been doing soil survey work in Arkansas for some years past. Not all of the results of their surveys are available. Some are out of print and some have not yet been published, but their contribution has been a very excellent one for a state where heretofore there has been little cooperation because of lack of funds. The following areas have been either wholly or partly surveyed by the Bureau of Soils:—Fayetteville area, Stuttgart area, Ashley County, Conway County, Prairie County, Miller County, Pope County, Columbia County, Mississippi County, Jefferson County, Yell County, Craighead County,

Hempstead County Faulkner County, Howard County, Drew County, and Lonoke County (not yet published.)

An act of the last legislature in Arkansas made it possible to begin detailed soil survey work in Arkansas in cooperation with the Bureau of Soils. This detailed work shows the variation of soils within each forty acre tract of land, accompanied by a map and the report. Under the new act the first county in which work was taken up was Pulaski. This proved one of the most difficult pieces of work ever carried on in the state, but was conducted with great thoroughness. The variation in soil types in Pulaski County is very great. The work has been completed and the map and report are being prepared at this time. Work in Baxter and Logan counties will be taken up during the summer. Next winter the work will be begun in Clay, Crittenden, and Bradley Counties.

It will, of course, take some years to complete a thorough survey of the state, but this work is too important to be neglected.

As soon as surveys are completed they are made the basis for further experimental work, resulting in the Experiment Station being able to give much more accurate advice to farmers in handling their soil problems.

#### GRADING CREAM INSURES QUALITY BRAND BUTTER

The purpose of maintaining a commercial creamery in the Department of Animal Husbandry and Dairying is to give the students in dairying every opportunity of first class instruction in a successfully operated creamery, also to furnish a good market for all cream produced in the immediate vicinity, and also to carry on research helpful to the industry in this state.

In order that it may be a model creamery, new and modern equipment has been installed in the past three years; and because of patronage in and out of the county, the creamery has become self supporting.

On June 1, 1921, a system of grading cream was installed by H. E. Dvorachek and R. H. Mason of the Department of Animal Husbandry and Dairying. By this method the patrons are paid for their cream on a butterfat basis according to the grade or quality. Patrons who deliver First Grade cream receive a premium of two cents per pound for butterfat above the general market price; those bringing in Second Grade cream receiving five cents less per pound for butterfat.

**1st Grade Cream** should have a mild pleasant taste, be free from curd lumps or foreign particles, and should be sweet or only slightly sour. It should have less than four-tenths per cent acid, more than twenty-five per cent fat, and no undesirable odor. This can be obtained when cream is properly cared for and delivered to the creamery as often as three times a week in the summer and twice a week during the winter.

**2nd Grade Cream** should consist of cream too sour to grade as firsts, but which is clean and palatable. It may be slightly curded or lumpy, but must not be puffy, yeasty, moldy or contain any bad odor.

It is the duty of this institution to instruct all interested in the best methods of caring for dairy products. It is needless to say that patrons appreciate the instruction and extra compensation as is shown by the fact that practically all are now bringing in First Grade cream. A new butter maker was employed in the summer of 1921 in the person of Mr. Wilbanks.

High grade butter can only be made from the best cream, and since this state enterprise holds itself as an example to other creameries operating in Arkansas, only the best cream is used in the manufacture of "Quality Brand Butter," thus encouraging patrons to bring their products up to first class standard.

Since using only First Grade Cream in the manufacture of butter, our business has increased practically 25 per cent and our butter is in greater demand than ever. The output of the University of Arkansas Creamery for the past year was 120,970 pounds of butter.

### BREEDING UP RAZORBACKS

In making an exhibit of market grades of swine for the 1920 Farmers' Week, three razorback sows were purchased at Hardy, Arkansas, to represent the lowest grade of market hogs, or "skins." It was then decided to retain them and breed them to good purebred boars and ascertain the improvement in the resulting pigs. The three sows with a heavy crate weighed altogether 380 pounds. They were from one to two years of age and showed a fairly strong infusion of Essex blood, but were in very low condition. They were put on feed with other hogs at the station and soon showed a much improved condition. The oldest sow was bred before reaching Fayetteville and farrowed nine pigs on January 9, 1921, presumably to the service of a scrub boar. She raised five pigs to weaning age, and they ran with other pigs and were marketed on August 25, 1921, in a car load shipment, and averaged 172 pounds at a little over eight months of age. Good care and feed produced a good growth even on scrubs.

In March, 1921, the two smaller sows farrowed litters to the service of a Poland China boar. One had a litter of nine and the other a litter of six. The litter of nine was marketed at five months of age as feeders and averaged 97 pounds. The litter of six was fed out, and on November 2, 1921, the four barrows in the litter were sold to a local buyer and they averaged at nine months of age, 194 pounds each. The two gilts were retained to be bred to ascertain further improvement in the second cross by pure bred sires.



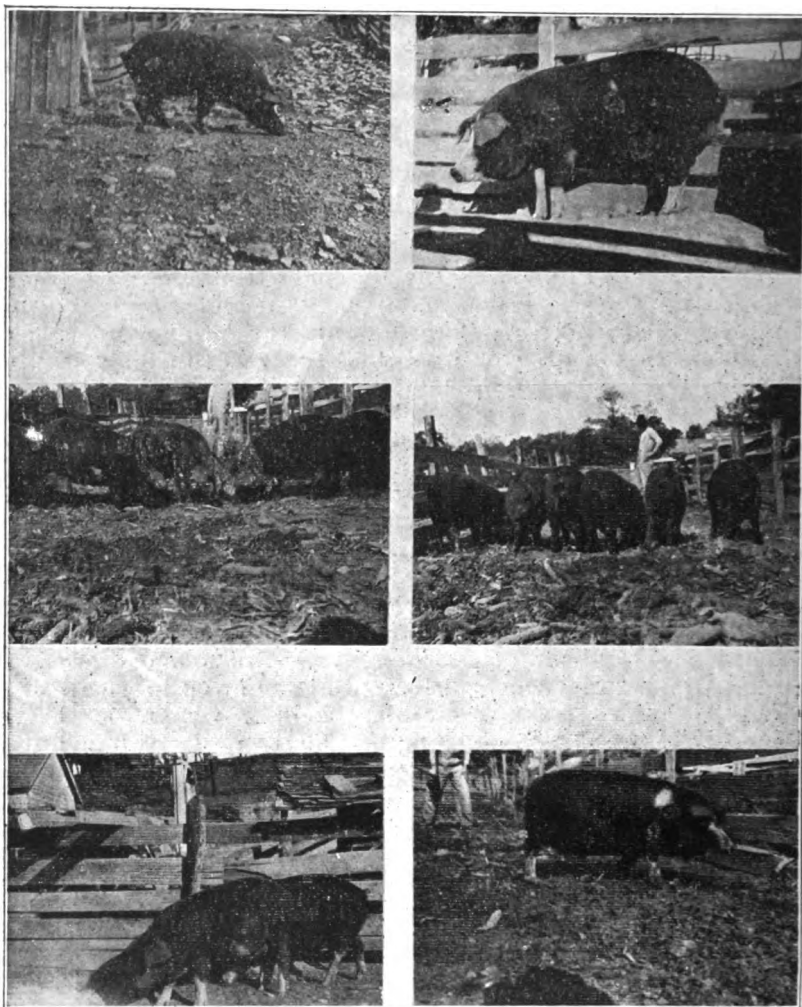


Figure 17.

No. 1. Razorback sow, weight 72 pounds when purchased.

No. 2. Young, pure bred Poland China boar used on sow.

No. 3. Front view litter from above mating, 6 pigs.

No. 4. Same litter, rear view.

No. 5. Gilt from above litter reared for second crossing.

No. 6. Barrow from above litter, sold at nine months, weight 194 pounds.

In the fall of 1921 two of the sows farrowed litters to the service of a pure bred Duroc Jersey boar. One farrowed a litter of ten pigs and died three days later with milk fever. All the pigs were lost but two gilts which we bottle fed and have retained for breeding. The other sow farrowed eleven pigs. Two of the gilts have been saved for breeding purposes, and the balance of the litter was marketed as feeders on February 10, 1922, at an average weight of 72 pounds at four months of age.

Results obtained thus far prove that low grade sows, when bred to pure bred boars, produce pigs of good type and good feeding qualities. Such sows and pigs respond to good care and sufficient feed about as well as improved stock. The two original sows were marketed recently, and although they weighed only 72 pounds and 85 pounds respectively when purchased, they went over the scale at 210 and 315 pounds respectively when sold. It all goes to show that the so called "Razorback" is a condition and not a breed in Arkansas. When the time comes in Arkansas that sows are not allowed to take their litters out on the range and be rebred to one of their own pigs; when boars of one breed are successively used and when more attention is given to proper feeding of pigs and fattening shoters, the Razorback type will disappear from the state.

### MARKETING BEEF CATTLE

One of the experiments, now being conducted with the grade herd of beef cattle owned by the Experiment Station, is to determine the best time, or rather the best age at which to market steers. A number of men, well informed as to the beef cattle industry, have repeatedly said and recommended that this country go in for the production of feeder cattle rather than finished beef. With the cheap pasture lands and good water which this country affords, the production of feeder stuff is made comparatively easy. In finishing cattle, however, the feeder in this section must necessarily come in competition with the corn belt feeder, who buys his concentrated feeds cheaper than they can be purchased here, has a climate more suited to economical gains in the feed lot, and the additional advantage of a shorter haul to market which carries a correspondingly reduced freight rate.

With these facts in view, the Department of Animal Husbandry, under Prof. H. E. Dvorachek, is making an effort to show by experiment which age and condition will give the greatest profit when steers are marketed. The tests will be made on two-year old steers, yearling stocker steers, and weaned calves.

The steer crop of 1920, from the grade herd, was grown until January, 1922, when they were placed in the feed lot on a ration of corn silage, broken ear corn, and cotton seed meal. They were sold May 15, 1922 on the Kansas City market.

The steer crop of 1921, from the grade herd, was run on pas-

ture with their dams until weaned, late in 1921, wintered on cheap forage (corn fodder), and sold in May, 1922, on the Kansas City market as yearling stocker steers. The steer crop of 1922 will be sold on the Kansas City market, when weaned, which will, in all probability, be about October, 1922.

The results with facts and figures will be published in a bulletin of this station to be issued during the coming year. While the results from the marketing of the weaned calves are not at hand as yet to compare with the figures on the fat two-year olds and the yearling stockers, the figures so far show conclusively that greater profits are derived from the production of yearling stocker steers than from the finished two-year olds.

The stockers are placed on the market at a time when there is a good demand for this grade of cattle to go on pastures in the corn belt. They had been produced on cheap pasture and cheap feeds. There were no charges for high priced concentrates against them. Considering the methods of production in this state and the trend of markets, the results from our shipments show it to be more profitable to produce yearling stockers than it is to produce two-year old finished steers.

#### SELF-FEEDERS FOR FATTENING SWINE

Four tests have been made by the Department of Animal Husbandry under Prof. H. E. Dvorachek and his assistants at this Station, with self-feeders for fattening swine to determine the economy of using it instead of hand feeding. The free-choice self-feeder, where the swine have a choice of unmixed feeds, was used. It has often been stated that swine, if given an opportunity, can balance their own ration better than can their feeder, and that more economical and more rapid gains can be made with the use of the self-feeder. The object of these tests was to prove or disprove these assertions, and also to determine the actual saving of labor through the use of the self-feeder.

In three of the tests made, the self-fed lot made larger daily gains than the hand-fed lot, but in the other test the hand-fed lot made slightly larger gains. The difference in rate of gains, however, was not very great in any of the tests. From these tests it would be safe to conclude that as far as rate of gain is concerned, carefully hand-fed swine can be made to gain as rapidly as self-fed animals.

As far as feed required to produce one hundred pounds of gain is concerned, it was found that in three of the tests it required less feed to produce one hundred pounds of gain in the self-fed lots than in the hand-fed lots. The amounts of feed saved varied from four to thirty-eight pounds. However, in the other test of the series it required twenty-one pounds of feed less to produce one hundred pounds of gain in the hand-fed lot than in the self-fed lot. Therefore, it would be safe to conclude

that as far as economy in the use of feed to produce pork is concerned the self-feeder has no great advantage over careful hand feeding.

It is as a labor saver that the self-feeder is at its best. Careful record was kept during the fourth and last test of the labor required to feed pens of ten shotes, each, by the self-fed and hand-fed methods. The average daily gains and feed required per hundred pounds of gain were so near alike that it is safe to conclude that both lots received fairly uniform attention. When figured at twenty cents per hour for labor and based on each one hundred pounds of gain made by each lot, it was found that it cost \$1.40 for labor alone to produce one hundred pounds of gain in the hand-fed lot, and only 43 cents per hundred pounds of gain in the self-fed lot. This saving in labor alone was sufficient to make the net profit on the self-fed lot greater, although the hand-fed lot in this test required less feed to produce a hundred pounds of gain.

In the hands of an inexperienced feeder, the self-feeder will show up to better advantage than with the experienced man because it will as a rule show greater gains, more economical gains, and less labor cost, but the great labor saving alone warrants its general use for fattening swine even with the best feeders.

#### INCREASED PRODUCTION DECREASES COST

When the First Arkansas State Egg Laying Contest was started at the Arkansas Experiment Station an experiment was also started in connection with the contest to determine the cost of producing eggs. The hens were not allowed free range, therefore, the figures are for the total amount of feed required.

The amount of feed required to produce a dozen eggs varies considerably, and this is due directly to the ability of the hen to produce. When the average of the birds in the contest was 137.6 eggs per bird, it required 9.53 pounds of grain to produce one dozen eggs. This was during the fourth contest. In the fifth contest the average per hen was 175.8 eggs, and the amount of feed required to produce one dozen eggs was reduced to 6.8 pounds of grain. The sixth contest had about the same average per hen and the number of pounds of grain required to produce a dozen of eggs was 6.3 pounds. Last year the amount required was 5.87 pounds.

From the above figures it is evident that when the flock average is around 170 eggs per hen, the cost of producing a dozen eggs will be 6.5 pounds of grain. The lower the average production the higher the cost.

In all the contests the Single Comb White Leghorns have produced a dozen eggs at less cost than any other breed. The amount of feed required has varied from 4.91 to 7.71 pounds, depending entirely on the average production. The Leghorns

usually have a higher average production and eat less feed. This accounts for the low cost of production.

The proportions of grain to dry mash have been almost the same each year. The past two years the amount of grain required to produce one dozen eggs has been 3.83 pounds and 3.5 pounds respectively. The amount of dry mash has been 2.47 pounds and 2.37 pounds for the same years.

The cost of production has been stated in pounds of feed rather than in cents because the cost of feed varies so much in different sections that it would be more or less misleading.

### USE MALES FROM HIGH PRODUCING HENS

Seven years ago it was decided by the Department of Animal Husbandry, S. R. Stout, Poultry Husbandman, to determine the length of time required to build up a high producing strain of chickens by using males from high producing hens. For two years there was very little progress made, due to the fact that it was difficult to get males from high producing hens. We have at the present time three males from high producing hens and are expecting some good results this laying season.

Already great strides have been made with the Columbian Plymouth Rocks. At the end of the First Arkansas State Egg Laying Contest, Mr. Sternberg, then of Pine Bluff, now of Stuttgart, gave to the University his pen of twelve hens. These hens had a ten months' record of 1012 eggs, or an average of 84.3 eggs per hen. The highest hen laid 120 eggs. These hens were mated to a male bird from a heavy laying strain and pullets kept from this mating. The pullets were entered in the third contest and finished in fifth place with an average of a little over 163 eggs per bird. The highest pullet laid 229 eggs during the year.

The following year, 1917-18, twelve pullets from the original mating were trap-nested and made records up to 184 eggs. Six of these pullets did not start to lay until January and therefore the record was for the ten months only. These pullets were mated in the spring to two male birds which were from hens with records up to 268 eggs. From these matings we obtained pullets that finished their first laying season with records ranging from 179 to 249. A pen of six pullets had the following record: 179-228-249-231-200 and 228. Pullets in other pens laid almost as well, and five others laid over two hundred.

It is interesting to note the increased production and to study the individuals. The pedigree of the hen that laid 249 eggs is a very good example of how high producing hens are produced. To start with, her dam was a pullet selected from a number of the original mating spoken of above. This pullet was not pedigreed, but was out of a hen with a record of not over 120 eggs for ten months. She laid 180 eggs in her pullet year and was mated to a male bird of a heavy laying strain. The result of this

mating is very evident, for the pullet kept from this mating laid 250 eggs in 365 days and laid 268 eggs before going into the molt during the last of November.

The Barred Plymouth Rocks have been bred up in the same manner with about the same results. The original pen was obtained from a general farm flock, and the first year had a very low average. This past year, 1921, a Barred Rock pullet, sired by a male bird from a hen with a record of over 200 eggs, laid in 12 months 235 eggs, another 215 eggs. Many of the pullets laid over 150 eggs. Only two laid as few eggs as the average of the Arkansas hen which is 66 eggs.

The progress made with White Leghorns has been somewhat slow due to the fact that the cockerels purchased proved to be of inferior quality as far as transmitting egg laying qualities was concerned. However, there has been a small increase and we have a 206 egg hen from a hen with a record of 177 eggs. This pullet is sired by a male bird from a 252 egg hen. Pullets from this bird are giving very good results at present.

If the production of the flock is to be increased, it is very necessary to use male birds from trap-nested hens that have made a good record.

#### INFLUENCE OF AGE OF HENS ON EGG PRODUCTION

The custom on the general farm is to keep hens which have outlived their usefulness as far as laying is concerned. A large majority of the young birds are sold as fryers or broilers because of the high prices paid for them. The old hens are kept from year to year without respect to their egg yield, and consequently without respect to the profit returned from the flock. It is the practice on commercial egg farms to sell the majority of the hens at the end of their first laying season. Only the exceptional individuals are kept the second year and then chiefly for breeding purposes.

In culling a flock in the fall it is always advisable to retain at least a third of the best year-old hens for breeders for the following spring. The old hens also lay a majority of their yearly production during the spring months when a large number of eggs are required for incubation. However, only the exceptional individuals, in regard to both vigor and production, should be kept after the first year.

In the poultry work of the Station, under Assistant Professor S. R. Stout, much work has been done along this line.

By keeping hens over a period of four years it was found that:

Hens lay the majority of eggs during their first two laying seasons, and especially during their pullet year if they are early hatched.

Old hens lay chiefly during the spring when the price of eggs is lowest.

The heavy producers in their pullet year are usually good producers their second year.

Poor layers in the pullet years are, with few exceptions, poor producers during succeeding years.

Only exceptional hens should be kept after they have completed their first laying season, and then largely for breeding purposes.

The mortality increased rapidly with the age of the hens.

The birds of the Mediterranean Class were more consistent layers during the three years than were the birds of the American and English classes.

The fourth year showed a greater decrease in production than did the third year, and the keeping of the hens was decidedly unprofitable.

### FEED LEGUME HAYS TO BROOD SOWS

The problem of getting brood sows through the winter in a condition suitable for normal farrowing in the spring has been puzzling swine growers for years. This is especially true of the mature sows. If they are fed liberally with concentrates, they become excessively fat, and if fed on a restricted ration they do not do well because their appetite for food has not been satisfied. Feeds rich in protein and mineral matter are also essential to insure strong healthy pigs. Where winter pasture is available, this difficulty is not so serious, but there are a great many breeders who do not have such pasture.

Two tests have been carried on at this station by the Department of Animal Husbandry under Professor H. E. Dvorachek with legume hays as supplements to corn for wintering brood sows. The legume hays contain both the necessary protein and minerals, and at the same time furnish the necessary bulk to satisfy the appetite. Alfalfa, cowpea, and soy bean hays were used in these lots and tankage was used in the check lot. The hays were fed in slatted racks where the sows had free access to the racks at all times. The sows were separated into lots after being bred, and were left in their respective lots until they farrowed. The pigs were all weighed twenty-four hours after farrowing and a record made of size and strength of individual pigs.

The cost of the ration was not reduced materially by using the legume hays instead of tankage, but it offers the feeder an opportunity to use home grown feeds instead of making a cash outlay for the purchase of a supplement.

The amount of hay consumed daily per sow varied with the kind of hay fed. The alfalfa hay was eaten with the least waste, and therefore, the requirement per day was the smallest. Only

.17 pounds daily per sow was consumed. The soy bean hay was wasted to the greatest extent as the sows did not consume the stems. They required .32 pounds daily per sow. The cowpea hay was consumed at the rate of .24 pounds daily per sow.

The results as shown by weights of pigs and percentage of strong pigs show that the hays were very satisfactory as supplements to corn. The average weights were very nearly the same in all lots. The cowpea hay lot showed the highest average weight per pig, but the lot also showed the smallest average number of pigs per litter. This lot also showed the highest percentage of strong pigs, which would naturally follow since the litters were the smallest in number of pigs per litter. No difference was noted as to the subsequent development of the pigs. The sows in the tankage lot made the largest gains, and were rather too fat at farrowing. All hay-fed sows were normal at the close of the test, and in good farrowing condition. All in all the legume hays may be pronounced as superior to tankage as supplements for wintering brood sows, especially from the farmer's standpoint.

#### SUPPLEMENT CORN WITH PROTEIN AND MINERALS

Feeding corn or any starchy feeds alone to young fattening shotes has proven very uneconomical and feeders have adopted quite generally the use of some protein supplements. Tankage has been accepted more or less as standard, but owing to the fact that it is rather high priced and often rather difficult to get in the smaller towns of the state, the Department of Animal Husbandry under Professor H. E. Dvorachek of this Station, has been testing out other high protein feeds as possible substitutes.

Cotton seed meal is by all odds the most easily obtainable high protein feed for this state. Serious prejudice exists in the minds of many as to the advisability of using cotton seed meal for swine feeding. For young growing pigs it is well to feed cotton seed meal in only very limited quantities, but for fattening shotes it can be fed in fairly large quantities if the fattening period does not exceed ten to twelve weeks, which is longer than the average fattening period. In one test at this station a pen of shotes was fed 25 per cent of cotton seed meal with corn for a period of ten weeks with no bad results, and the gains were larger and more economical than in the corn and tankage lot. Cotton seed meal should be supplemented with minerals for best results.

Another high protein feed which has proven valuable and which should be more generally used is peanut meal. In several tests made of this feed at this Station, it has proven more palatable and more efficient than tankage when properly supplemented with minerals. With increased production of peanuts in the South, this feed should be easily gotten anywhere in the state.

Dairy by-products such as skim-milk and buttermilk make



excellent supplements for both growing and fattening swine. In tests at this Station with fattening swine, it was proven that larger and more economical gains could be made with skim-milk and buttermilk than with tankage. These by-products are more especially valuable for the growing pigs as they contain food accessories necessary for normal growth known as vitamins.

Linseed oil meal is also a very valuable protein supplement for swine, but is not very easily obtained in the South.

More recent investigations show that it is not only necessary to supply additional protein to get best results, but that the supply of mineral matter must also be supplemented. This can be done by using commercial mineral mixtures or using one commonly recommended and used quite frequently by farmers and feeders. It is made of the following ingredients and proportions:

#### MINERAL MIXTURE FOR HOGS

Finely ground limestone, or slacked lime, one part  
by measure;

Common salt, one part;

Soft coal or charcoal, one part;

Hardwood ashes, one part;

To every one hundred pounds of this mixture, add  
five pounds of flour of sulphur and three  
pounds of copperas.

The mixture can be fed in a trough or self-feeder where hogs have free access to it at all times and where it will be protected from rain. The mixture also acts as a vermifuge as well as supplying minerals necessary for proper growth and body functions.

#### FORAGE CROPS PRODUCE CHEAP GAINS

The practice of feeding hogs in a small dry pen or lot from weaning time to maturity is fast disappearing. It has proven very expensive. This is especially true now that packers do not look with favor on heavy, excessively fat hogs. It is indeed questionable whether or not this practice was ever economical for Arkansas conditions. The state as a whole is better adapted to forage growing than to grain growing, and it looks as though swine growers could make more profit during the growing period than during the fattening period by the liberal use of forage and grazing crops.

For a number of years Professor Dvorachek and his assistants in the Department of Animal Husbandry have been doing forage crop investigational work with swine. Acre and half acre plots have been planted to various crops and the crops harvested or "hogged off" by turning in swine. It has been the plan to provide some forage crop throughout the year. In order to do this

it has been necessary to resort to winter grains for winter and early spring pasture, and they have proven very satisfactory. In the tests made winter rye furnished more pasture both during winter and spring than either winter oats or winter wheat. In order that it furnish good winter pasture it should be sown early in the fall so as to get well established before growth is checked by cold weather. This should be no later than the fore part of September for Northwest Arkansas.

Following winter grains one can have rape alone or with oats sown in February ready to pasture. Such a crop can be ready by the first of May. This season, tests are being made on the best way to sow rape for hog pasture. Plots sown broadcast, drilled with grain drill, and drilled in two-foot rows, as well as different rates of seeding have been put out. In Northwest Arkansas a good permanent pasture of tame grasses such as orchard grass or blue grass with white clover or legume crops such as red clover and alfalfa can also be used for early spring pasture following winter grains.

Work with Alfalfa and Red Clover as pasture crops clearly shows that they are both very desirable pasture crops for swine. Alfalfa has several advantages over Red Clover as shown in our tests. When once well established it will be practically permanent if not overstocked, while clover dies the second year, right at a time when pasture is hard to supply. As far as value is concerned, the red clover, when at its best, the second spring, proved equal to Alfalfa as a grazing crop, but its period of maximum usefulness is rather short.

For the summer period of July and August, cane and cowpeas sown in May or early June at the rate of one bushel cowpeas and one bushel cane per acre provided considerable pasture, but the value of this crop is not great as indicated by gains made by the hogs. A good permanent pasture of Alfalfa or some mixture of tame grasses should be provided for this period. Where Bermuda grass grows well it would offer a solution for this period.

For fall pasture a larger variety of crops can be used both for growing and fattening. Rape can be sown in September, and if not pastured too heavily can be used until early winter. Rape in all cases must have good soil for best results. Legumes such as soy beans, cowpeas, and velvet beans, grown with corn, can be used to good advantage for fattening. Spanish peanuts and sweet potatoes can also be used to advantage where soils are adapted for their growth.

One of the great needs of the state is more permanent pastures for livestock. The annual crops are good, but are rather expensive when one figures labor, seed, and all; neither does their use decrease the labor during the busy season. The following mixture is being established this season to test out its value

as a permanent pasture in Northwest Arkansas. The amounts of seed mentioned are per acre: Orchard grass, five pounds; Timothy, five pounds; Kentucky Blue grass, five pounds; Red Top, three pounds; Red Clover, two pounds; and Alfalfa, two pounds. This mixture was sown early last fall and the clover reseeded this spring as it was killed by the dry weather last fall. This crop will be allowed to grow until July, when a crop of hay will be taken off and stock kept off until fall to let the crop get well established. This mixture has variety and should provide good pasture from early spring to fall.

Similar tests will be made in other parts of Arkansas as soon as land and funds can be obtained.

### USE OF PURE-BRED BEEF SIRES

The College of Agriculture maintains a herd of grade cattle on the Experiment Station farm at Fayetteville, for the purpose of demonstrating the value of pure bred beef bulls when crossed on low grade cows. Other experiments, such as feeding, marketing, growing calves, pasture trials, etc., are also conducted with the herd, and are reported in these articles. Prof. Dvorachek and Ass't. Prof. H. E. Reed are devoting part of their time to this work.

The original cows were purchased on the Kansas City market in the spring of 1918. They were the poorest grade to be found on the market at that time. As far as type was concerned they were nondescript, except as to being far from desirable beef type. Long narrow heads, long thin necks, rough open shoulders, narrow backs and loins, slab sides with no spring of ribs, narrow, peaked quarters, long legs, with high flanks more nearly describes them. Three kinds were selected—one kind showing a trace of Shorthorn blood, another showing Hereford blood, and another showing Aberdeen Angus blood, but the traces of the blood of these three important beef breeds were distinguishable only in color. The grade Shorthorns were red or roan, the grade Herefords were red, showing white faces, and the grade Angus were black, being polled in some instances, but not all. With these cows as the foundation herd, the grading up experiment was started.

The bulls used on the grade cows were the bulls from the purebred herds owned by the College. At the beginning of the experiment the bulls owned by the College were not the best examples of their respective breeds by far. However, they were good beef bulls, and had the ability to transmit to their offspring good beef conformation and the ability to put on flesh easily. The bulls now being used on the grade cows are excellent examples of their respective breeds, and a marked improvement can be expected in our future calf crops, and more especially from the second and third crosses.

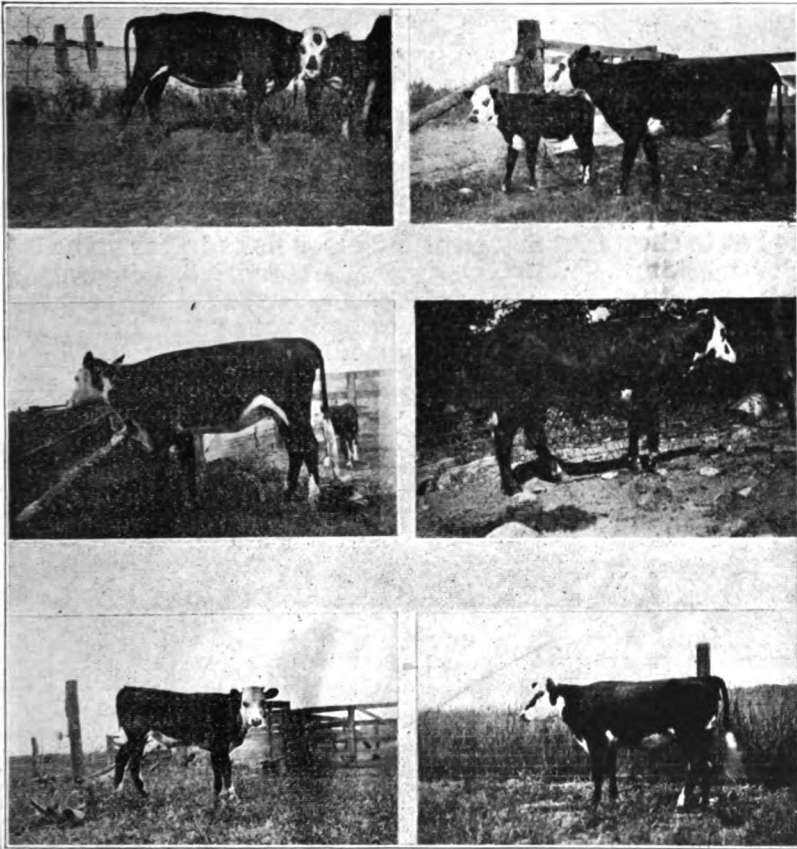


Figure 18.

1. Cow No. 1, Original low grade cow.
2. Cow No. 2, out of Cow No. 1 by pure bred bull, first cross.
3. Calf out of No. 2, by pure bred bull, 2nd cross.
4. Cow No. 5, another of the original low grade cows with her 1922 calf by bull in Fig. 19.
5. Two year old steer out of cow No. 5 above by bull in Fig. 19.
6. One year old heifer out of cow No. 5 above by bull in Fig. 19.

From the start of the experiment the heifer calves, sired by pure bred bulls and out of the grade cows, have been retained in the herd and when of breeding age have been mated to pure bred bulls in order that the second and additional crosses from pure bred sires might be observed. The bull calves have all been castrated and used in steer feeding and marketing experiments.

Unless it is possible to actually see these cattle, the improve-

ment made in the grading-up work can best be seen from pictures. (The pictures used in this article were made from individuals in the grade Hereford herd. This breed was selected for the illustrations because we have the second cross from it, and not from the other breeds.)

Cow No. 1 is one of the original cows purchased in Kansas City. She was bred to Sir Simoon 46th, a registered Hereford bull, and dropped to this service cow No. 2 on March 28, 1919. A study of the picture of cow No. 1 will convince one that about all she has to show that any Hereford blood flows in her veins is her color markings. Notice the long narrow head, denoting poor feeding qualities; the rough open shoulders, a feature very rarely found in Herefords; the uneven top line; the peaked rumps with drooping tail head, and "cat hammed" thighs.

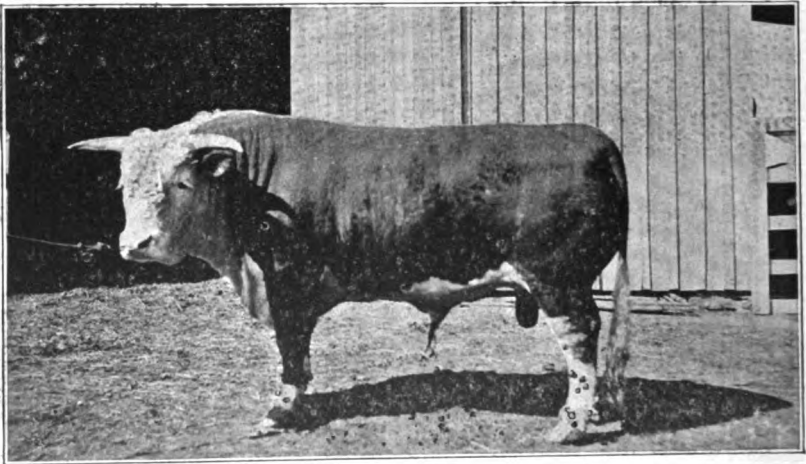


Figure 19. Pure bred Hereford bull used on grade herd.

The cut of number 2, while showing the cow at a disadvantage, shows many good points inherited from the sire. In her we find a more typical beef head, smoother shoulders, greater depth of body, straighter top line, and more development in the rump and hind quarters. Quality is another characteristic in which this cow excels her dam, and she undoubtedly inherited it from her sire. No. 2 still shows the leggy appearance, this feature being one of the hardest to breed out, but we are now using a bull which we are confident will shorten the legs of his calves to a marked degree.

Cow No. 2 on reaching maturity was bred to the bull shown in Fig. 19, another pure bred Hereford bull, used for a time in the College herd. From this mating the cow dropped the

calf shown in figure 4. In this calf, we are approaching nearer to desirable beef type. The short broad head is associated with good feeding qualities. The rest of the calf's conformation is easily seen to come more from the sire than from the dam. Notice the blocky, deep body, smooth in the shoulders, and well developed in the hind quarters.

Cow No. 5 is another of the foundation cows, shown with her 1922 heifer calf sired by the bull shown in Fig. 19. As evidence that the heifer is not unusual, in figure six and seven we are showing a steer dropped in 1920 by cow number five and a heifer dropped in 1921 by cow number five, both being sired by bull in Fig. 19. Cow number five is very similar in type and conformation to cow number 1, and in all three of her offsprings the changes and improvement over her are so noticeable that they are easily traced to the good features of the sire.

That, in a word, is the real value of a pure bred sire. He has been bred for a number of generations by breeders who have a standard or ideal. The undesirable features have been bred out, and the desirable qualities improved and bred into him. With such breeding back of him, he has the ability to transmit these same features to his offspring.

The aim of the College of Agriculture in conducting the work explained in this article is, and has been, to show to Arkansas farmers the good a pure bred sire will do, and what may be expected from him when crossed on low grade cows.

### WINTERING AND FEEDING GRADE BEEF COWS

Another of the trials now being conducted by the Experiment Station with the grade herd is an experiment to determine the most economical and efficient feed, (taken from the cheap roughages) on which to winter a beef herd under Arkansas conditions.

During the greater part of the year, these cattle are run on pasture, being put on as early in the spring as possible and being taken off only when the grass will no longer keep them. Up to the present time, only native grasses, with the exception of rye in the winter and early spring, have been used. Mixtures of several grasses have been sown recently, and reports on the results of these new pastures in comparison with native grasses will be available in the near future. Naturally, the condition in which the cattle go into the winter depends on the grass which they have run on during the fall, and the gains they make in the early spring depend largely on the way they wintered. Coming from winter feeding in poor condition and going on to rye pasture, they will make good gains. On the other hand coming out in good condition, and going out to new washy grass, which has not grown enough to carry any substance, they will lose very noticeably. For early spring pasture, we have found that it is

better to use rye, sown in fall, until the pasture grasses have grown to such an extent that they have lost the washy, watery condition and have more substance.

For winter feeding, three different forages have been used.

During the winter of 1919-20, a roughage of cane and soy beans was used. The cane and soy beans were planted in rows in July after wheat had been cut from the ground. The forage was cut with a corn binder, shocked in the field and fed from the shock. Until December 1, the cattle were on pasture, from December 1 to January 1 they were given the run of a stalk field, and from January 1 on were fed the cane and soy beans. They were in thin condition when they went on the roughage.

The following winter, 1920-21, they were handled in the same manner up to January 1 as they had been in the fall of 1919, and they were in better condition than the previous year. From January 1, 1921, until grass time, they were fed corn silage and cotton seed meal.

In 1921-22, they were handled up to January 1, as in previous years, and from January 1 to grass time they were fed shock corn.

In amounts, all three years, the cattle were given what feed they would clean up readily twice a day.

Comparing the results of the three winters feeding, we find that the corn silage and cotton seed meal gave the best results, and at the same time was the most expensive of the three feeds. The cattle were in good condition when going on this feed and made substantial gains while on it. Reducing the price of cane in 1920 to its 1922 value, the cane and soy bean feeding was done at practically the same expense as the feeding of shock corn. Both gave about the same results as far as conditioning the cattle goes. The cane and soy bean hay has the advantage, however, of making it possible to utilize a second crop off of wheat land, while the production of shock corn requires an entire season's use of the land.

All three of the feeds gave good results, and the recommendation of any one of them would depend on the cost of production of the crop. The outstanding fact gained from the feeding work with the grade herd is that cattle of this kind can be satisfactorily wintered on cheap roughages without the use of concentrated feeds, and the kind to use depends wholly on the cost of the feed.

### BETTER SILAGE BY ADDING A LEGUME

The department of Animal Husbandry and Dairying of this Station is carrying on investigations with silage. The object is to determine if the addition of cowpeas or soy beans to corn or cane will improve the quality and yield of the resulting silage.

Professor H. E. Dvorachek and R. H. Mason are supervising this work.

Two years work with cowpeas has proven that it is not practical to use this crop to supplement corn in silage making. The greatest difficulty lies in handling the crop to advantage. When grown with the cane, the combined crop is very hard to harvest in a mixed condition. When grown separately the additional labor necessary to properly mix them at the ensilage cutter makes the practice questionable. The resulting silage has, in a test with dairy cows, proved to be five per cent more valuable than cane silage.

Work with soy beans and corn grown together in drilled rows has been very satisfactory. A tall, rank, forage growing variety of soy beans should be used. The combined crop can be harvested without difficulty with a corn binder, and thus handled to good advantage. In the one test made on this combination, the yield per acre of the mixed crop was 7.6 tons per acre, while straight corn produced only 6.8 tons per acre on the same type of soil. In a test with dairy cows, the mixed silage proved ten per cent more valuable than the straight corn silage. This is a mixture that can be highly recommended. Live stock growers who have tried it around Fayetteville say they will never go back to straight corn.

Work with soy beans and cane drilled in rows 40 inches apart, following a crop of either oats or wheat has been carried on for two years. For want of a suitable planter the seeds were mixed and planted with a grain drill, stopping up the holes to the desired width. This crop is a second crop and can rarely be put in before the middle of July. The crop is then cut with a corn binder, and is therefore easily handled. In most of the state this crop will mature as it did here in the fall of 1921. The heads of the cane should be well matured to insure good silage. In the fall of 1920 the crop was slow growing on account of the dry summer, and was damaged by an early frost. The resulting silage was of very inferior quality. Further work with this mixture will be done this season.

### THE BEEF CATTLE HERDS

The College of Agriculture owns and maintains, at the Experiment Station at Fayetteville, herds of beef cattle of the three most important beef breeds, Shorthorns, Herefords, and Aberdeen Angus. These cattle are used for two purposes:

1. For instruction of students.
2. For experimental work.

These objects are accomplished best by maintaining small herds of very high quality, because of the lack of equipment for maintaining large herds. Besides using these in experimental work and for instruction they are shown from time to time at



county and state fairs, to a limited extent, so that their quality may be tested in competition with the product of other breeders.

**Shorthorns.** In the Shorthorn herd the College of Agriculture and Experiment Station are carefully breeding a pure roan herd, descended from Avondale, the great Carpenter and Ross bull. The head of the College herd is Dale, by Double Dale, by Avondale and out of Wellington Amanda IV. He is a splendid type of Shorthorn bull for Arkansas, and took grand championship at the Arkansas State Fair. He is likewise used upon the grade herd in the experimental work in breeding.

Among the pure-bred cows we have Susanette, of straight Avondale breeding; Susanette II; the Arkansas grand champion heifer Sweetheart; and two heifers of Dale's 1921 get. Also a white heifer presented to the institution by Lewis Brothers, prominent breeders of Northwest Arkansas. This white heifer is out of Serene, by Orange Cumberland. This herd of Shorthorns was shown at Springfield, Missouri, the Washington County Fair, and the State Fair at Little Rock. In each case they made a very creditable showing against good competitors. At the State Fair the herd obtained seven first prizes, senior champion bull, grand champion bull, junior champion heifer, senior champion cow, and grand champion female. In addition to this, Arkansas Searchlight, a pure bred Shorthorn yearling steer, bred by O. W. Carlson of Bentonville, sold to the University, and fitted and exhibited by it, won first in his class and grand champion steer of the show. Later this steer was sold back to Mr. Carlson who took him to Kansas City to the Central Shorthorn Breeders' Sale and Show in March, 1922. There, in competition with steers from Missouri, Kansas, and other states, he was placed first in his class, and was sold at auction in Kansas City for \$9.75 per hundred. He weighed 1270 pounds at that time and was a little over one year and seven months of age.

**Herefords.** The College of Agriculture and State Experiment Station acquired in the summer of 1921 a small, but excellent herd of Hereford cattle for instructional and also for experimental breeding purposes. All but one of the cows and the herd bull are of straight "Anxiety IV" breeding. The herd bull is Brummel Elect, by Valiant Brummel, out of Lady Elect 19th, purchased from Messrs. Wallace and E. G. Good of Grandview, Missouri. He is one of the best of his breed in the state. The cow herd consists of five breeding cows, two yearling heifers, and two heifer calves, all of the very best type of breeding. Some of these were shown at the State Fair last fall. (The bull was not purchased until this spring). The cows took 1st and 3rd three-year old; 1st two year old; 2nd junior heifer; 2nd junior heifer calf; 2nd junior bull calf; senior champion cow; and grand champion cow.

**Aberdeen Angus.** The Angus herd consists of the herd bull, four cows, two two-year old cows, two yearlings, and two heifer calves. These are all of excellent type, and several of the offspring are giving fine promise. The herd bull, for several years, has been Heather Brilliant. He was lately sold in Arkansas because all of the young female stock are sired by him. He took first in his class, and senior champion at the State Fair. Other prizes were: 1st junior heifer calf; 2nd aged herd; 2nd produce of dam; 2nd in get of sire; 2nd junior yearling bull; 3rd three-year old cow; 3rd two-year old cow; 3rd senior heifer calf. A young bull loaned to the University by the Fagus Plantation of Missouri is being used the present year. The breeding work of this herd is also carried over into the grade herd.

All three of these beef cattle herds are seen annually by thousands of farmers.

### DAIRY CATTLE

The College of Agriculture and State Experiment Station has three breeds of dairy cattle: Jerseys, Holsteins, and Ayrshires. These are kept for breeding purposes, for instruction of students, and also for experimental work in feeding, cost of production, etc. The entire herd consists of thirty-three head.

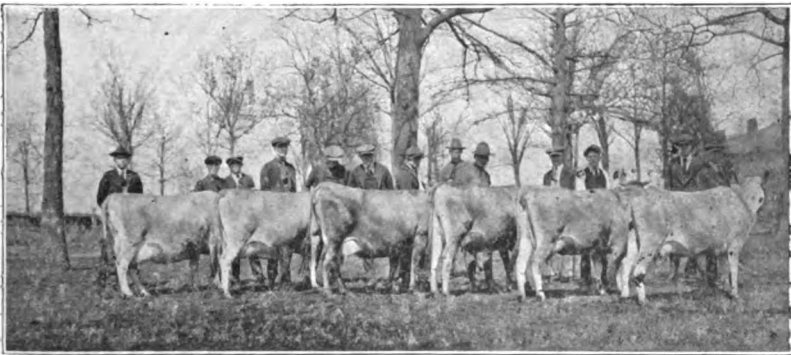


Figure 20. Pure bred Jersey cows, Experiment Station Farm.

**Jerseys.** For some years past the Institution has been breeding Jersey cattle. The stock owned is straight, line-bred Eminent stock. During the past ten years the College has used two sons and two grandsons of Imported Eminent in the herd. Improvement in the herd is noticeable. The plan of using half-brothers as sires successively will be carried still farther if a suitable Eminent sire can be secured for the next step. Every female of milking age in the herd has a Register of Merit record. The first sire we used was Susie's Eminent. Two of his daugh-

ters made excellent records. The next herd sire was Owl's Royal Eminent. One of his daughters, owned by the College, was Pearl's Alpha, champion butter fat producer of the state over all breeds and all ages, with a record of 553.84 pounds of butter fat, and 10,239.6 pounds of milk as a senior three-year old. Another daughter, Arkansas Fairy, produced 472.71 pounds of butter



Figure 21. Pure bred Holstein cows, Experiment Station Farm.

fat as a five year old. Two other daughters of this bull are now on test. One of them, Owl's Golden Jubilee will probably be the next state champion, with a record approaching 600 pounds of butter fat. Betty's Eminent was the next sire used. One of his daughters, Arkansas Fairy 2nd produced 373.2 pounds of butter fat as a junior two-year old, which is the record of the state for that age. A son of this bull, out of Pearl's Alpha, is being retained for use in the herd in the future. Other bulls by this sire are being used in Northwest Arkansas with good showings. The present head of the herd is Bowmont Eminent, son of Imported Eminent. One of his daughters, Cynthia's Golden Babe, has a record of 550.84 pounds of butter fat in a year's test. Four other daughters of this bull are young heifers in the herd; one, the daughter of Pearl's Alpha, another out of Arkansas Fairy 2nd and another out of Jubilee. Part of this herd was shown at Little Rock last fall, taking a number of first and second prizes.

**Holstein.** The breeding of Holsteins was begun in 1917 by the purchase of three females and a bull. The cows are: Madison Jennie Friend, record, 512.86 pounds of butter fat in a year and 18,873.7 pounds of milk; North Star Jennie Beets, 446.24 pounds of butter fat and 14,528.9 pounds of milk in a year; and the other cow is Dalles Friend Madison Jennie, with a record of 497.12 pounds of butter fat and 14,603.9 pounds of milk as a four-year old. The last cow has three daughters in the herd, all excellent prospects. The herd bull is Dalles Colantha Johanna

Lad. He has eight daughters in the herd, three of them now milking as two-year olds. The first one produced 204 pounds of butter fat in 112 days. These heifers will, without doubt, surpass their dams. As a junior sire the Station was able to obtain Dalles Colantha Johanna Friend, grandson of the former world's champion Colantha 4ths Johanna, thus making it possible to line-breed the Holstein herd.

One son and four daughters of the three original cows by the original herd sire were shown at the Arkansas State Fair, resulting in 1st senior yearling bull; junior champion bull, and grand champion bull; 1st senior heifer calf; junior champion female; 2nd and 3rd senior yearling heifers; 4th senior heifer calf; 1st get of sire; first young herd; 2nd produce of dam.

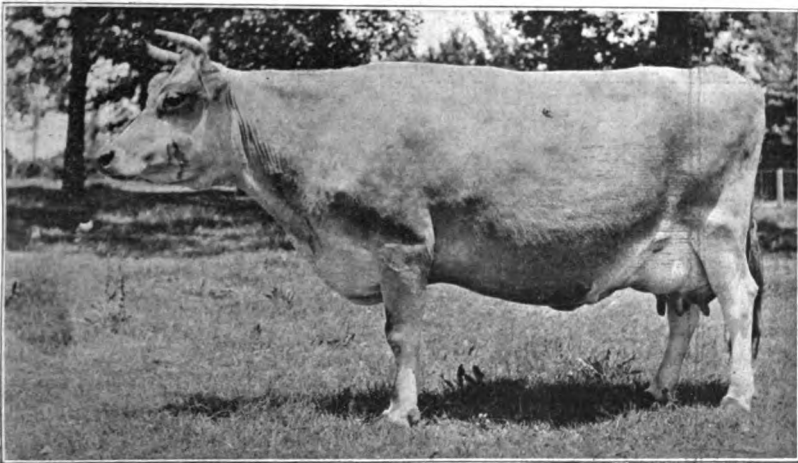


Figure 22. Cynthia's Golden Babe, pure bred Jersey cow, record 550 pounds butter fat.

**Ayrshires.** The Ayrshire herd consists of three cows, all well-bred, and all producing better than 400 pounds of butter fat.

All of these herds are being used in experimental work, in the cost of milk production, the use of silage and other dairy feeds, as well as in the work of breeding-up and increasing production. No heifer has been retained in the herd that did not produce 300 pounds of butter fat or over as a two-year old. Thus far only one heifer has had to be discarded because of low production.

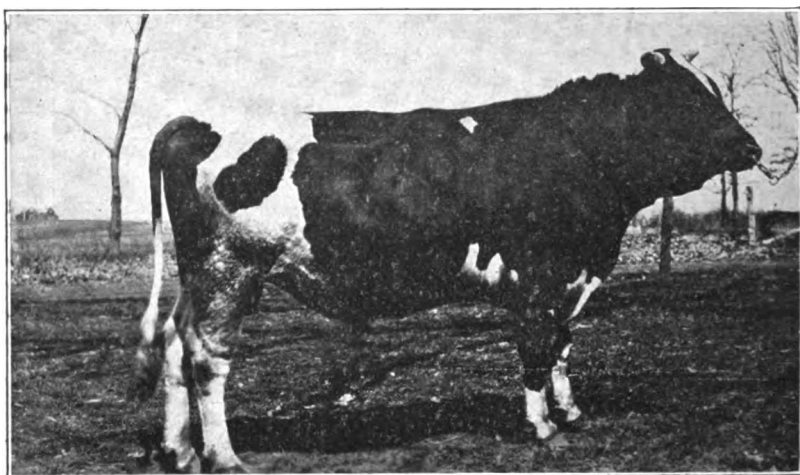


Figure 23. Young Holstein bull, Colantha Johanna Jennie Beets, Grand Champion bull Arkansas State Fair. Bred and produced by State Experiment Station.

### INFECTIOUS ABORTION OF CATTLE

A disease preventing reproduction would be fatal to the cattle business. Where cows fail to get with calf, where any considerable number of them abort or lose their calves before maturity or give birth to dead or weak calves at full period, there is something seriously the matter. Of late years a disease known as infectious abortion has been attacking herds of cattle throughout the United States. This is an infectious disease characterized by severe inflammation of the uterus or womb of pregnant cows, affecting the membrane surrounding the fetus, and in a large number of cases this results in the premature birth of the calf, and therefore a failure of the "calf crop." The disease is most prevalent in sections where the breeding of cattle is most extensive. In some sections seventy per cent of all cattle herds are infected. The disease is of the greatest economic importance for the reason that it causes the loss of the calf, possibly permanent sterility of the cow, and practically always a decreased milk flow.

This disease is caused by a bacillus or germ (*Bacillus abortus*, Bang.,) which selects the mucous membrane of the pregnant uterus or womb as its location for growth. In about sixty per cent of infected cows this organism is present in the udder, where they may remain for months or even years. When the cow becomes pregnant they move to the uterus or womb, and by increasing there cause inflammation and the resulting abortion.

After the abortion or birth of the calf they are eliminated from the womb or uterus in from three weeks to two months. Some of the bacteria of this disease are expelled with the fetus and are found in its stomach and intestines and in the other membranes expelled at the time of the abortion. They contaminate soils, feed, hay, and other substances.

The infection passes from cow to cow in two ways: by the discharges spoken of above contaminating feed and water, and by the milk from the udder of an infected cow.

For years the bull was regarded as the important factor in the spread of the disease, but recent experiments by the Bureau of Animal Industry tend to show that this is untrue. Bulls may become infected and throw off the germ, but probably do not infect the cow by injecting it into the womb at the time of service.

Dr. W. L. Bleecker and Dr. J. E. Syferd of the Departments of Bacteriology and Veterinary Science have been conducting experiments to find out how this disease is transmitted. They are testing methods of its control. If among the cattle on any farm there are a number of abortions the farmer should consult a good, recognized authority on this subject. The presence of this disease may be positively shown by one or two biological tests which can be performed only by trained bacteriologists. If a sample of blood from a cow that has recently aborted can be taken and sent in to the Experiment Station of the College of Agriculture at Fayetteville it will be tested free of charge. The sample should be taken by a trained veterinarian.

No medicine will cure infectious abortion. A number of different methods of treatment have been devised, but none of them have proven effective. The disease may be controlled by the following precautions:

First, isolate in a pen by themselves all cows which have aborted, and keep them where other stock cannot get to them until all discharges from the vagina have ceased.

Second, heifers should not be allowed to come in contact with infected cows at any time. Calves get rid of the infection shortly after birth, and if heifers are not infected while pregnant they do not abort.

Third, the bull should not be allowed to run with the herd, but should have his own individual lot. A separate small lot should be provided in which cows are bred. Neither the cows nor the bull should be permitted to get into this lot or remain in it at any time other than when being bred. After service the cow should be kept in this inclosure until there is no danger of her discharging semen from the breeding.

Fourth, the aborted calves and afterbirth and any littered or grass or straw or other material which has become soiled or touched should be burned. If in the barn, the floors should be cleaned with some disinfectant.

There are two methods of vaccinating against infectious abortion. The method by use of dead culture has not proven entirely successful. A second method is by the use of the live germs. Under strict experimental conditions this method usually cuts down the number of abortions to a considerable extent. However, the live culture method should not be used except on a tested herd where the disease is absolutely known to exist, and **then only by the highest skilled and most reliable veterinarians.** This disease must be carefully watched in Arkansas. It is known to exist in the state, and the Experiment Station will continue its work regarding methods of control.

### INFECTIOUS ABORTION OF SWINE

This disease attacks pregnant sows in practically the same way as the same type of disease attacks pregnant cows. The results are the same, loss of pigs, failure of reproduction, and all of the economic losses that these things mean. This disease is not so widely distributed as that of cattle, but it is showing up in heavy hog-breeding districts.

It is caused by an organism very similar, if not identical, with that causing the disease in cattle. It is impossible to tell the difference between the two organisms with a microscope. They have the same reaction to tests.

The infection acts in swine in the same manner as in cattle. It is transmitted apparently in the same way, mainly through consumption of contaminated food.

Dr. W. L. Bleecker of the Department of Bacteriology of the State Experiment Station has been conducting experimental work with hogs, to show whether the milk from infected cows, when fed to hogs, will produce abortion in pregnant sows. It has been impossible to give the disease to pregnant sows by feeding them milk from infected cows either before or after getting with pig. He has even fed sows pure cultures from organisms from infected cows, and in no case has he been able to make the sows take the disease. However, other experiments have shown that, when organisms from cows are injected into the veins of the sows, abortion was produced in a number of cases. The work of this experiment is not fully completed, but these results are important.

Whether the boar acts as a disseminator of the disease among sows or not is a question that has not been definitely decided. In all probability infection from the boar must be taken in by the sow consuming food contaminated by the boar rather than by the injection of contamination into the womb by the boar. This is the same as with bulls and cows.

This disease may be determined by examination of the blood exactly as in the case of cattle.

No medicine will do any good. The following rules for control are important:

First, the newly aborted sow should be kept separate from the rest of the herd.

Second, the aborted pigs, the afterbirth, and all membrane as well as all of the bedding should be burned and the pen thoroughly disinfected.

Third, the boar should be confined in a lot by himself.

Fourth, sows should not be allowed to eat aborted calves or pigs or the afterbirth from aborted cows or sows.

Fifth, precautions regarding breeding should probably be the same as with cattle.

The following are some of the facts that are known about infectious abortion of swine:

1. That in swine this disease is caused by an organism that cannot be differentiated from the organism which causes the disease in cattle.

2. That sows are rather resistant to *B. abortus*, Bang. of bovine origin.

- (a) They cannot be infected by feeding the milk from infected cows.
- (b) They cannot be infected by the feeding of pure cultures *B. abortus*, Bang.
- (c) Sows may become infected after eating the aborted calves or pigs and the afterbirth from aborting cows or sows.
- (d) Sows will become infected after receiving an intravenous injection of bovine *B. abortus*, Bang.

### SOME INSECT PESTS

**The Codling Moth.** The codling moth, or apple worm, is the most important insect attacking the apple fruit. Its control depends upon keeping the fruit protected by an arsenical spray during the entire period of hatching of apple "worms" so that the newly hatched "worms" are poisoned before being able to enter the fruit. In Arkansas there are two distinct periods of hatching, one during which larvae of the first generation or "brood" hatch and the other during which larvae of the second, third, and fourth "broods," which overlap, hatch. To successfully combat this insect, the fruit grower should be able to know a week or ten days before hand the exact time the first hatching of each brood will occur in order that a spray application may be made in time to protect the fruit. The Department of Entomology, Profs. W. J. Baerg and Dwight Isely in cooperation with the U. S. Laboratory at Bentonville, are giving this service to fruit growers. To secure this information for the growers, several thousand codling moth are reared annually in cages in



the insectary is as near natural conditions as possible. The method of procedure is as follows:

Apple "worms" are collected in fall and pass the winter in their cocoons in cages. As they transform to moths and emerge from their cocoons they are removed to other cages and fed dilute honey, where with favorable climatic conditions, they may mate and deposit eggs. Sometimes egg deposition begins within a few days, but often a long interval, of a month or more, may elapse between the first emergence and first egg deposition. The moths are kept under daily observation, and when the first eggs are recorded the time of hatching of the first larvae may be predicted. With the cooperation of the Extension Division, this information is sent within a few hours to the fruit growers that they may have ample time to spray. Timing of the later broods is carried out in a similar manner. The success of the plan has been fully demonstrated.

It is the intention of the department that this codling moth service shall be carried on indefinitely.

**Strawberry Weevil.** No other insect is more destructive to strawberries in Arkansas than the strawberry weevil, which cuts off the flower buds before blooming. This insect occurs in a number of the strawberry sections of the state. Wherever it occurs, one of the striking peculiarities is the extreme variation in degree of infestation between different fields and often between different parts of the same field. It has been found that in some instances at least extremely heavy infestations are due to weedy fence rows and brush near the fields in which the weevils found unusually favorable protection in winter. Control of the weevil by dusting with arsenate of lime is being tried. While this method is considered promising, it is still in the experimental stage for this region.

**Eastern Strawberry Louse.** As a part of strawberry insect investigations, attention was given to a plant louse feeding on the under sides of strawberry leaves. The insect was found to be entirely new to science and was named "The Eastern Strawberry Louse." It has not been observed as being of great importance, but as all plant lice are given to periodic outbreaks, it must be regarded as potentially important.

**Striped Cucumber Beetle.** One of the most serious setbacks of the commercial production of canteloupes, watermelons, and cucumbers is the striped cucumber beetle. Injury is most serious to seedlings just after they come up. Feeding upon the leaves and stems at this time usually necessitates replanting of a large percentage of hills and in some instances destroys an entire planting. In preliminary experiments for the control of this insect, it has been found that arsenate of lead applied at the rate

of two pounds, powdered, to 50 gallons of water gives the best protection to seedling plants. It is effective, however, as a repellent rather than as a killing agent.

**Control of the Peach Tree Borer.** The tedious practice of "worming" peach trees each fall has been depended on for years in all commercial peach sections for the control of the peach tree borer. This practice is now being superceded by poison gas treatment with paradichlorobenzine. This chemical is a crystalline substance, which on exposure to air slowly gives off a heavy gas. In treating peach trees, one ounce per tree is used. The soil around the tree should be removed to a depth of about one-half to one inch. The crystals are placed in a strip around the tree about an inch away from the bark. The earth is then replaced and mounded around the trunk of the tree. In Arkansas the treatment should be made the latter part of September, and the earth removed about a month later. Paradichlorobenzine treatment is more effective than the old-fashioned practice of "worming" and is also much cheaper. This treatment should be used only on trees at least six years old as it may injure young trees.

**Cotton Insects.** With the addition of a second man to the Entomology Department, a project on cotton insects has been undertaken. Until the year 1922, it was impossible to give more than a small amount of attention to cotton insects because the entomologist had to carry the teaching work and all the experimental work also. Now, for the first time, the department is making a study of cotton insects. This study will cover not only methods of control of the boll weevil but also the red spider, cotton leaf worm, boll worm, pink boll worm and other insects injurious to cotton. This work has been begun.

## FRUIT AND VEGETABLES

The Department of Horticulture, under the direction of Prof. J. R. Cooper, and Asst. Prof. C. W. Rapp, operates an experimental tract on the Station farm at Fayetteville, consisting of sixty acres which is planted to both fruits and vegetables. Practically all of the varieties of fruits and vegetables which can be grown in the State are found here. In addition to the regular Experiment Station farm, the department is operating fifteen acres all set to different kinds of fruits and vegetables for student laboratory work, where students do practically all of the work connected with the operation. Co-operative experiments are being carried on in apple orchards at Springdale, in Washington County, and Bentonville, in Benton County; in peach orchards at Cabin Creek, in Johnson County; and in the cantaloupe and melon fields at De Queen, in Sevier County.

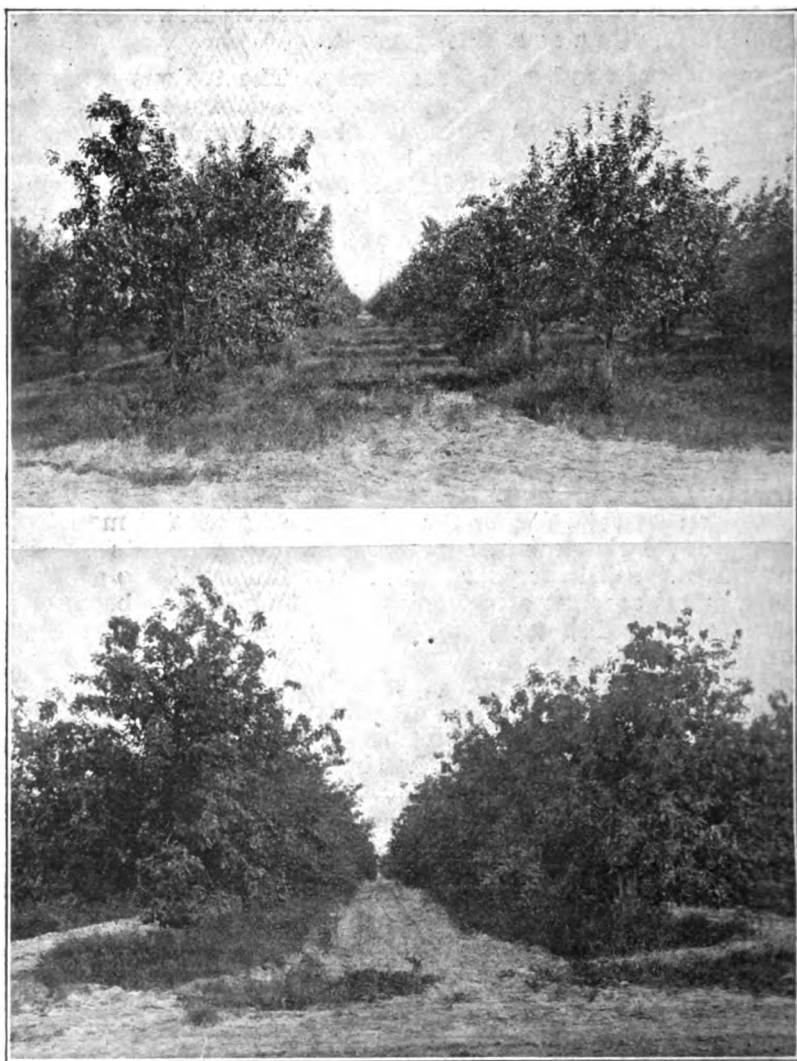


Figure 24. Two views in Station orchard. Above, sod. Below clean cultivation and cover crops.

### FEEDING FRUIT TREES

Some very definite results have been obtained in the experimental work with different fruits. Some varieties are more nearly self-sterile than others, but the same principles that make

some kinds of fruit self-sterile have a tendency to create the same conditions in others. Factors which render one kind susceptible to frost injury, also have a tendency to make others susceptible. Different varieties respond to the same general principles of fertilization; the differences lying principally in the amounts of fertilizing elements required, and the time of application.

**Fertilizers for Apples.** The yield of apples has been materially increased by the timely use of quickly available nitrogen, in some instances; in others, by a combination of nitrogen and phosphorus; in others by a combination of nitrogen and stable manure; and in still others, by the use of barnyard manure alone. This increase in yield is due: first to the greater number of blossoms which set fruit; and second, to the greater number of fruits which remain on the tree to maturity. The fruit crop for the following year is greatly increased, due to the greater number of fruit buds which are formed.

Results of experimental work clearly establish the import-

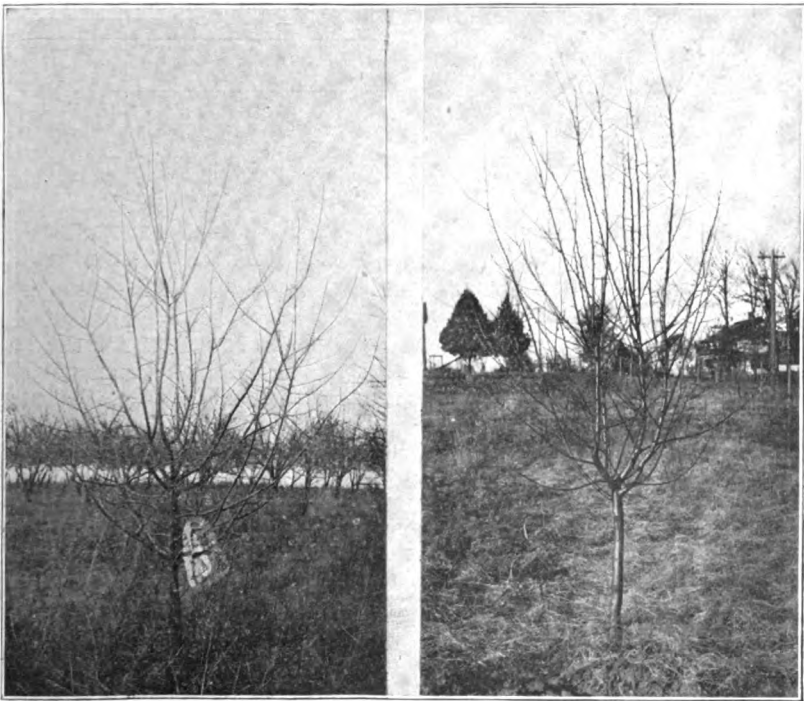


Figure 25. The right and wrong way of training apple trees. Tree on left will last longer and bear heavier crops than one on right.

ance of humus, and show definitely that the practice of continual clean culture in orchards, or in fact in any fruit plantations, is detrimental, unless barnyard manure is used consistently. Even where barnyard manure is used, constant cultivation quickly depletes the humus. Humus may be supplied where stable manure is lacking, by growing and turning under some such crop as cow-peas, rye, clovers, vetch, etc. Even where stable manure can be had, a cover crop of rye through the winter, prevents soil erosion and conserves plant food to a great extent.

Nitrogen gives the most decided and the quickest results, and the quickly available nitrogen, such as nitrate of soda, or sulphate of ammonia, give much better results than the more slowly available forms, such as cotton seed meal, tankage, etc. The general results show a slight advantage in favor of nitrate of soda over sulphate of ammonia. In orchards where the soil is short in nitrogen, an application of nitrate of soda early in the spring—three to four weeks before the trees bloom—will cause a much higher percentage of blossoms to set fruit than where it is not used. An application just before the June drop causes a correspondingly greater number of apples to remain on the trees to maturity.



Figure 26. Rye ready to disk in as a cover crop in apple orchard in spring.

The ideal way to apply nitrogen is to make a part of the application in the early season, and a part of it just before the June drop. One application early in the season, will often an-

swer this double purpose, but is attended with some disadvantages. A heavy excess of nitrogen just before blooming, may result in a rapid growth of foliage, and in a reduction in the number of normal flowers, and consequently a reduction in the set of fruit. Some of the nitrogen is lost in leaching and runoff. Fortunately, there is little danger of over dosage under Arkansas conditions. In some instances a light application of nitrogen late in the summer is desirable, to keep the foliage growing normally until late in the fall. In the Station experiments, this late application has been found to result in some instances, in a fall crop of fruit buds.

The best results have been obtained by using about two and one-half pounds of nitrate of soda per average tree, for the early application; and about the same amount for the June drop application. Nearly equal results have been had, however, by using five pounds at one application, and applying it early. In orchards where the humus content is fairly well maintained, only the light, early application has been found necessary.

Phosphorus has given less direct results than nitrogen, due, no doubt, to the fact that it is often present in sufficient quantities in the soil of the average orchard. In some instances,

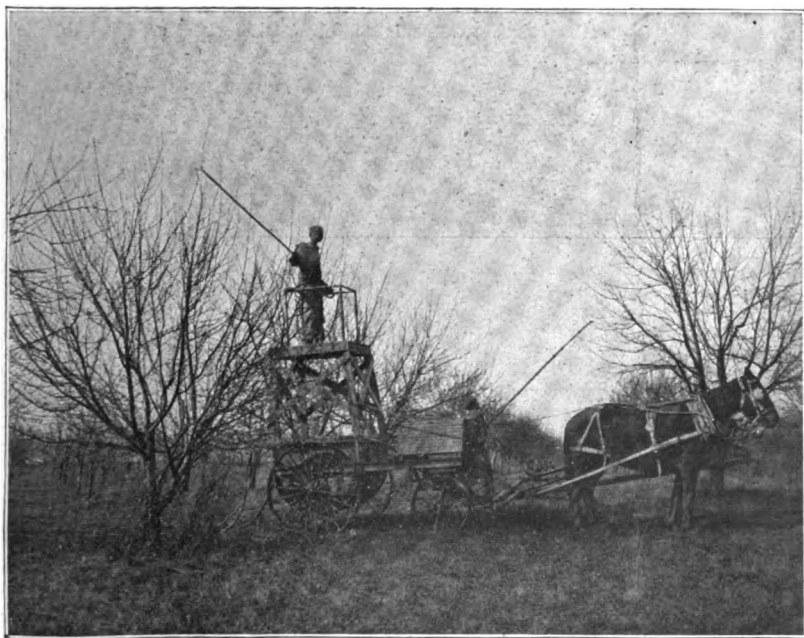


Figure 27. Putting on the dormant spray. Experiment Station orchard.

however, a greater number of fruit buds have resulted from the use of acid phosphate. The greatest good from phosphorus fertilization comes, in an indirect way, from the larger cover crops grown between the trees, and hence, largely to the accumulation of humus in the soil. Often these cover crops, especially clover and rye, will not make a satisfactory growth without the addition of phosphorus. In the ordinary bearing orchard, three to four hundred pounds per acre, applied every other year will be sufficient.

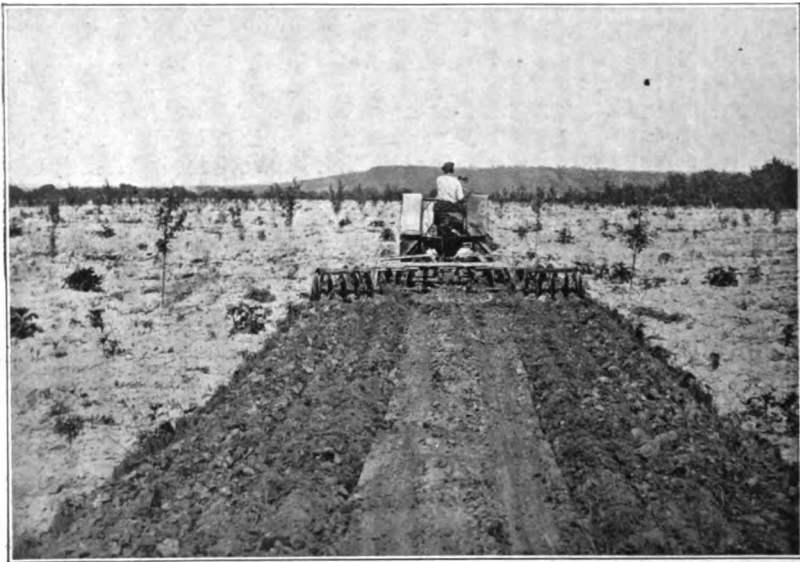


Figure 28. Cultivating young orchard with disk and tractor. Experiment Station Farm.

Thus far, potash has given no results either in the set of fruit, the formation of fruit spurs, or in the total crop.

Fertilizers in general have given the best results when scattered evenly all over the area among the trees.

In young orchards, especially on poorer land, a combination of cowpeas and rye gives very excellent results. The cowpeas are grown in the middles during the summer and turned under about the first of July, and rye planted as soon as soil conditions are favorable. Red clover is another excellent cover crop for young orchards. It is allowed to grow in the middles for two years at a time, then plowed under and the middles either cultivated for a season, or planted to some crop which requires cultivation. Barnyard manure applied at the rate of ten tons per acre every other year, will furnish an adequate supply of humus



Figure 29. Cover crops on young orchard. Right, phosphorus and nitrogen. Left, nitrogen only.

in young orchards, but even here a cover crop should stand on the ground over winter, to prevent erosion and loss of plant food.

Newly set trees respond very favorably to an application of about five or six ounces of nitrate of soda per tree, well scattered around the tree, after growth has become well established. The amount of nitrogen used should be doubled each succeeding year, until the trees are three or four years old.

Acid phosphate at the rate of three to four hundred pounds per acre has been found to be a paying investment. Acid phosphate need not be applied, however, more than every second year. It is often necessary to make an application of acid phosphate before satisfactory results can be had from cover crops.

**Fertilizers for Peaches:** Results show that the same general fertilizing principles hold good with peaches as with apples. Only the quickly available forms of nitrogen give satisfactory results. The slowly available forms of nitrogen are less satisfactory with peaches than in the case of apples. Slowly available forms of nitrogen give practically no results during drouthy seasons. The benefit to be derived from the quickly available forms, such as nitrate of soda and sulphate of ammonia, depend upon having an adequate supply of moisture in the soils. Hence, the peach orchard must be well cultivated during the season when the fruit is growing and maturing. Peach trees require more nitrogen in proportion than apple trees, but there is more danger of using an over dose early in the spring than in the case of apple trees. Two and one-half to three pounds of nitrate of soda is sufficient to furnish nitrogen to the average peach tree



throughout the growing season. For best results this should be divided into three equal parts: the first application being made two to three weeks before the trees bloom; the second, just before the May or June drop; and the third, as soon as the fruit is harvested, or about the last of July. The first two applications operate in just the same way that nitrogen fertilizers operate in fertilizing apple trees. The third application keeps the tree growing vigorously until frost, and does away, to a large extent,



Figure 30. Experimental peach orchard showing clean cultivation, ready for cover crop.

with frost injury to the buds. Where only one application of nitrogen is used, the dosage should be reduced to one and one-half to two pounds per tree, early in the season. Peach tree foliage has a greater affinity for water than the fruit, and, in seasons of drouth, the fruit on trees, even where well supplied with nitrogen, is liable to be very small owing to the fact that the leaves rob the fruit of water.

Phosphorus gives greater direct benefits as a fertilizer for peaches than for apples. Slightly more wood growth is made and the number of fruit buds which actually set fruit is considerably greater than where no phosphorus is used. Here again, however, as in the case of apples, the greatest results come from the increased humus supply from cover crops grown among the trees. The ideal cover crop combination for this purpose is cow-peas planted in the middles four or five weeks before the peaches are to be harvested, plowed under about the first of September, and rye planted as a cover crop for winter.



Figure 31. Effect of nitrogen on growth of peach trees. Left, 3 pounds of nitrate of soda per tree before bloom. Right, no fertilizer.

Potash has given no direct benefit either in tree growth, or setting of fruit.

### GRAPES

The Department of Horticulture has a vineyard containing nearly two hundred varieties of grapes, in which all lines of experiments which may furnish information of value to growers are being carried on. In addition to the Station vineyard, co-operative work is being carried on with some of the growers at Tontitown.

**Fertilizers:** Nitrogen has proven of less importance in fertilizing grapes than in fertilizing tree fruits, due largely to the fact that grapes bloom much later than tree fruits. One hundred to one hundred and fifty pounds of nitrate of soda per acre is the amount which has given the best results. The nitrate of soda should be scattered all over the middle between the rows about the time growth starts in the spring. Very good results have been had from the use of about two hundred and fifty to three hundred pounds of acid phosphate scattered all over the middles. Acid phosphate need not be applied oftener than every other year. Humus is found to be one of the most important factors in grape production. Fertilizer experiments conducted on soils devoid of humus have given little results. As in the case of tree fruits, it has been found that humus can be supplied readily by barnyard manure. In the absence of barnyard manure it can be supplied by growing cover crops between the rows after the fruit is harvested. The department has had good results from using the

cowpea and rye combination. By using rye alone sowed in the fall and allowed to make fairly heavy crop over winter, and plowing it under the next spring, the supply of humus has been well kept up.

**Uneven Ripening.** The Department of Horticulture has received many complaints in regard to small bunches, uneven ripening of bunches, and poorly developed fruit. Experiments were undertaken to determine the cause of this trouble and how to overcome it. It was found to be largely a question of fertilization. Feeding the plants so that they can grow and develop in a normal way has practically eliminated the trouble. Proper training and renewal must accompany proper feeding, however.

**Pruning and Training.** In connection with the study of uneven ripening of grapes, the department took up various methods of pruning and training. The experiments show that bunch grapes give the best results when trained to a single stem, with canes of medium length arising very close to the trunk. If long arms of old wood are allowed to develop, small bunches and uneven ripening are likely to result.

The largest bunches and the best fruit are obtained from standard varieties like Concords, when about thirty fruiting buds are left on each plant in addition to the spurs left to furnish wood for the coming year. These thirty buds should be distributed among canes about seven buds long. On normal canes the weight of fruit produced increases from the first to the third bud, is about the same on the third, fourth, and fifth bud, and is much reduced on the seventh bud. On the average, only about seven buds on each cane produce fruit, regardless of the number of buds which are left, and in cases where more buds produce fruit on the same cane the bunches are usually small and uneven. A plant with four well placed canes six to seven buds long will bear as much fruit under the average conditions as plants with more canes, or with four canes ten to twelve buds long, and the fruit will average much better in quality.

**Summer Pruning.** Various amounts and times of pruning have been practiced with only negative results. The removal of suckers, bull canes, etc., has proven beneficial; but the tipping back of canes during the summer, and general summer pruning, proves detrimental rather than beneficial.

**Varieties.** The Concord has been accepted as the standard commercial grape, due to the fact that it is used largely in the production of grape juice and that it is the accepted American table grape for the United States. Several of the varieties grown in the Horticultural vineyard excell the Concord in many ways and are much more desirable for home plantings. Some of them, however, do not stand shipping, and hence, can not compete with

Concord as commercial varieties. Commercial plantings in Northern Arkansas should be confined principally to Concords, although Moore's Early, Worden, King, and Hicks, will prove profitable planted in limited quantities. For home consumption and local sales, the Catawba, Delaware, Campbell's Early, Brilliant, Brighton, and Niagara, will prove very desirable in addition to the above list. The Delicious is a black grape which fills a long felt want of a late maturing grape. This grape ripens in late September. The Rotundifolia grapes, such as James, Scuppernong, and others, have proven unsatisfactory in the Ozark region, except where planted in a limited way for home consumption. These grapes will, however, give good results in Southern Arkansas.

### CANE FRUITS

To meet the various inquiries coming in from different parts of the State, the Department of Horticulture has established a planting of a large number of different cane fruits. Arkansas is the natural home of blackberries and dewberries, and as has been expected, these fruits give wonderful results in both yield and quality.

**Fertilizers.** Cane fruits have about the same requirements in the way of nitrogenous fertilizers as grapes. There is one difference in application. The seasonal amount of nitrogen should be divided into two applications: The first, early in the spring when the plants first begin growth; and the second, as soon as the fruit is harvested. Three to four hundred pounds of acid phosphate, applied every other year, will furnish sufficient phosphorus. Humus must be furnished either by the application of ten to fifteen tons of barnyard manure every other season, or by growing cover crops between the rows after the fruit is harvested. In growing cover crops, especially rye, the seed should be drilled rather than broadcasted, to avoid having to hoe among the plants.

**Varieties.** The Early Harvest blackberry is the most largely grown early variety in the northern part of the State. This is a heavy bearing variety during favorable seasons but becomes seedy and unpalatable under drouthy conditions and the crop is often reduced to a large extent. It is also very susceptible to rust.

The Snyder, while not high in quality, is a very excellent commercial berry for Northern Arkansas. It is a much more vigorous grower than the Early Harvest, and is less susceptible to rust, but is more exacting in fertilizing requirements.

The McDonald is a very excellent berry for southern conditions. It is largely self-sterile, and of more or less trailing habit. The self-sterile factor may be overcome by inter-planting with other varieties which bloom at the same time. The Depart-

ment of Horticulture finds the Early Harvest blackberry blooms at the same time and is an excellent pollinizer, but the susceptibility of this variety to rust makes it somewhat undesirable. The Austin dewberry also blooms at the same time and proves a good pollinizer, but its trailing habit often makes it undesirable. The Lawton blackberry has proven to be a very good berry to interplant with the McDonald. The Haupt blackberry, which is a cross between the blackberry and the dewberry, is also very desirable for this purpose.

The Lawton blackberry is itself a very excellent variety for southern conditions. The Dallas and the Eldorado are both very promising for Northern Arkansas, and will give good results farther south than the Snyder.

### STRAWBERRIES

The increase in production of strawberries over the State has made it necessary for the Department of Horticulture to do considerable experimental work with this fruit. Experiments have been confined largely to fertilizers, and testing varieties.

**Fertilizers.** The use of small amounts of nitrogen gives good results, but care must be exercised as to time and manner of its application. Nitrogen can be used with safety in the summer after the fruit is harvested. Smaller amounts may be used early the next spring, but no nitrogen should be applied after growth is well established. One hundred to one hundred and fifty pounds of nitrate of soda per acre may be used profitably where applied in the summer after the fruit is harvested. If nitrogen is not applied until early spring, not more than one hundred pounds per acre should be employed. Even this, in some instances, has proven too much.

Slowly available nitrogen carriers, such as cotton seed meal, dried blood, bone meal, etc., are safest to use on strawberries. Bone meal makes a very excellent strawberry fertilizer, since it contains both nitrogen and phosphorus, and the nitrogen is in a fairly slowly available form.

Barnyard manure is a very reliable fertilizer when well rotted and applied after the fruit is harvested. It should not be used in the spring after the growth has started. Fresh manure should not be used at any time on bearing fields.

Phosphorus has given greater direct results on strawberries than on any other fruit. Phosphorus not only increases the crop of berries, but increases the shipping quality. Two to three hundred pounds of acid phosphate applied annually, or larger amount applied every other year will give good results.

**Varieties.** The Klondyke is the standard variety over most parts of the state. While it is very desirable to confine the acreage to one variety until car lot shipments can be made, Northern

Arkansas should make a considerable percentage of its planting to a later variety to avoid competition on the market.

The Aroma is a very desirable berry, coming on about ten days after the Klondyke. Growers in Northwest Arkansas would profit by increasing the acreage of Aromas and reducing the acreage of Klondykes.

### TO MAKE SPRAY MATERIAL SPREAD AND STICK

Spray material in practical work often fails to spread and stick to the leaves and branches and other parts of the tree and form a complete protection. There are any number of commercial substances now on the market intended for this purpose. This fact led the Department of Horticulture to try out some of these preparations for the purpose of seeing whether they would actually cause the spray material to spread and stick. The department used some of the commercial casein spreaders this year. They have been found to give what appears to be a more even coating of the spray on foliage and fruit and apparently a more complete cover is obtained more easily with them than without them. From a practical standpoint this would prevent mottling of the fruit. But only one year of work has been done and no test has been made to prove whether this in any way interferes with or changes the value or efficiency of the spray material. No recommendation can be made on one year's trial.

The early application of lime sulphur often causes considerable damage from spray injury, or burning, especially during bad weather. As a practical method, the Department of Horticulture has tried using five pounds of freshly slaked stone lime or about six pounds of hydrated lime to each fifty gallons of spray material with good success in preventing the injury.

The department has found that a great deal of the inefficiency in spraying lies in insufficient power to keep up the required pressure under field conditions, and by using nozzles which are not properly fitted to give desired results.

### IRISH POTATOES

The Department of Horticulture has been experimenting with Irish potatoes along practically all lines. Some very striking results have already been secured, while other phases of our investigations are still being continued.

**Fertilizers.** Experiments show a decided benefit from the use of commercial fertilizers, although no one formula has been found which will fit all soils. The fertilizer which has given the most general results under the greatest number of soil conditions, but which will have to be modified to meet various local conditions, is from four to six hundred pounds of a fertilizer consisting of about eight percent phosphorus, three to four percent

nitrogen, and nothing to two percent potash. Barnyard manure has given very excellent results, and should be used whenever it can be procured. For the most satisfactory results it should be applied to the land the year before the potatoes are grown. Fresh manure encourages insects which are injurious to the tubers, where used the same year the potatoes are grown.

As with many other horticultural crops, humus has been found to be a very important factor in potato production. The department has found that land entirely depleted of humus gives

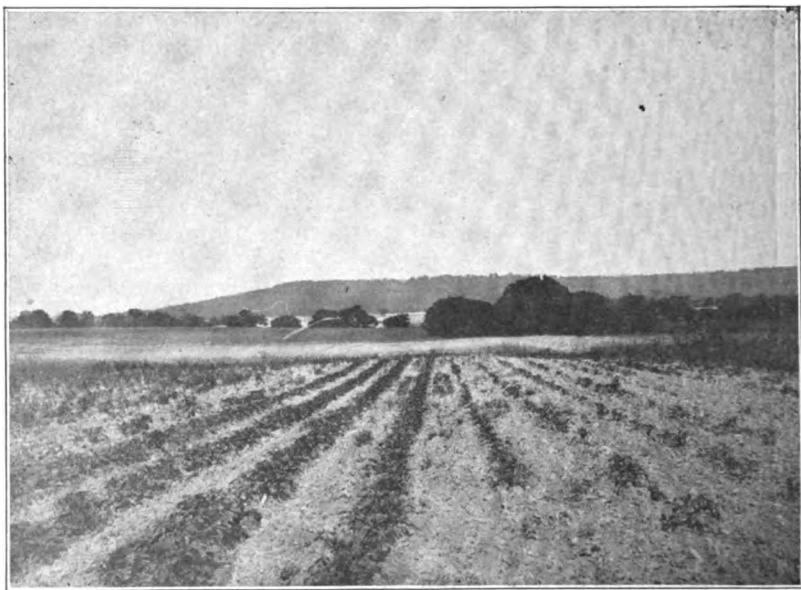


Figure 32. Testing northern grown certified Irish potato seed. Left, high yielding seed. Right, worthless strain.

very little returns, even from the use of large quantities of fertilizers. The production of potatoes on the Experiment Station farm has been raised several hundred percent over the average of the state, by the use of fertilizers and humus.

**Certified Seed.** For several years the Department of Horticulture, in cooperation with the United States Department of Agriculture, has been testing potatoes grown in different parts of the United States, for seed in Arkansas. Certified, as well as uncertified stock has been used. Some very superior strains of Triumph seed stock have been found. Several of even the certified strains, have given only fair results, and others have been entirely unsatisfactory. The department unhesitatingly recommends the use of certified seed, but must caution the purchaser to

exercise due care in buying. Not all certified seed is desirable. The mere fact of certification may not mean superior seed stock, as far as Arkansas conditions are concerned. The buyer should demand a certificate showing an official count in percentage of diseases present, the yield, and other qualifications noted in certification.

**Fall-Grown Seed.** In connection with the tests of Triumph potato seed from other sources, the Department of Horticulture has been producing and growing fall-crop seed, and procuring such seed from other sections of the state. The results show the crop from this seed to be a week to ten days later than northern grown stock, a little lower in yield, and not quite so free from mosiac as the best strains of the northern certified seed. Such seed has been found good, although on the whole, not quite so desirable as the best strains of northern grown certified stock.

**Germinating Potatoes for the Fall Crop.** Considerable difficulty has been experienced by growers over the state, in procuring a good stand for the fall crop, due in many instances to poor germination. The department has been able to overcome this to a large extent. The best method is to dig the potatoes while the vines are still green, after the potatoes are fully matured, but while the skin will still slip. The tubers must not be exposed to the sun, and must be stored at once in slatted crates in a cool, well ventilated place. After being held under such conditions from two to four weeks, they are cut and planted in the regular way.

**Varieties.** At the present time the Bliss Triumph variety is grown almost to the exclusion of all other varieties commercially. Tests made by the Department of Horticulture show, however, that the Irish Cobbler is a better and more dependable commercial variety than the Triumph. Under good conditions the yield is much larger and it is easier harvested. The larger yield is due to two factors; it sets more tubers, and is much more resistant to mosiac than the Triumph. It may, under certain circumstances, prove a few days later than the Triumph, although, on the Experiment Station farm, the two varieties are harvested at the same time.

## SWEET POTATOES

The Department of Horticulture has carried on experiments with sweet potatoes for a number of years relative to cultural methods, fertilizers, harvesting, storing, etc. The results, in a number of instances, have been very gratifying.

**Fertilizers.** The fertilizer experiments have shown that sweet potatoes require about the same kind and amount of fertilizers as Irish potatoes, except that the nitrogen requirement is somewhat lower. Where an 8-4-2 fertilizer will give good results



on Irish potatoes, an equally good result has been procured with sweet potatoes by using an 8-3-2 formula.

Potassium has, to date, given only negative results.

The need of humus has been demonstrated even more forcibly than with Irish potatoes. On the same land the part not supplied with humus yielded only one hundred and fifty bushels, while another portion well supplied and well fertilized, produced over six hundred bushels to the acre.

**Varieties.** According to the results obtained by the Department of Horticulture, two varieties of sweet potatoes stand out above all others; the Nancy Hall, and the Porto Rico. The Big Stem Jersey, which has been exciting considerable comment on meaty fruits. According to these standards, the records of the proven only an indifferent yielder, averaging only about one-half of the amount of marketable potatoes produced by the two varieties mentioned.

In keeping qualities, the Nancy Hall and the Porto Rico are about equal. Under good conditions of growing and storage, the Big Stem Jersey holds up about as well as the two already mentioned, but if weather conditions at harvesting time are not just right, it does not keep well. Last year the department lost nearly all of its Big Stem Jersey potatoes, stored in the same building and under the same conditions, where the Nancy Hall and the Porto Rico kept well.

**Selected Seed.** Satisfactory crops can be had only when good seed is used. The Department of Horticulture has also found that there is a great deal of difference in yielding qualities of otherwise good seed. In producing the best seed, tubers must be selected with a good performance record for yields, as well as disease resistance. The department has on hand at present, a number of high yielding strains, which will later after multiplication, be distributed to growers.

## TOMATOES

**Varieties.** A high class commercial variety of tomatoes should have high yielding plants with large, well shaped, solid, meaty fruits. According to these standards, the records of the Department of Horticulture show that Chalk's Early Jewel, Bonny Best, and June Pink, rank in the order named. Of the main crop, or cannery variety, Greater Baltimore, Red Rock, Livingston's Perfection, and Stone, rank in order named.

**Mulching.** Tomatoes, mulched with wheat straw, have produced higher total yields on the Experiment Station farm than unmulched plants, and they fruit over a longer period of time.

**Pruning and Staking:** Pruning reduced the total yield of fruit, but prolongs the growing season. The fruits averaged

larger when pruned and staked, and produced a greater percentage of marketable fruits; but ripe fruits were not produced quite so early as on unstaked plants.

### FROST INJURY TO FRUIT BUDS

While it is impossible to entirely eliminate frost injury, and thus prevent the loss of fruit crops from this source, the Department of Horticulture has been able to eliminate a great deal of this loss. Investigations show that frost injury is very closely correlated with poor cultural methods and management. Among horticulturists there is a term known as "irritability." Irritability as understood by horticulturists is the factor which permits, or causes, trees to start to grow or allow the buds to swell during early periods of warm weather. Such fruits are much more susceptible to frost injury than those which remain dormant through the winter. Fruit trees also have what is known as a resting stage; that is, for a certain period of time after growth is completed the tree remains almost completely dormant, during which time, of course, fluctuations of temperature have no effect upon it unless they are extremely severe. Where the trees go into their resting period just as cool weather comes on, there is much less danger of frost injury throughout the winter and following warm periods in the early spring. It is obvious then, that we should allow the tree to go into the resting period just as late as possible. This is especially true of peach trees. Peach trees which shed their foliage early in the fall, for any reason, go into their resting period earlier than those which retain their leaves until frost. Any factor then, such as, drouth, lack of fertilizers, lack of humus, improper spraying, and poor cultural methods, which will encourage the dropping of leaves, and hence, hasten the resting period, makes the trees just that much more liable to frost injury.

Resistance to frost is also influenced to some extent, by the amount of plant food elements taken up by the trees and stored in their tissues, and hence, by the amount of fertilizers supplied to the tree. A loss of fruit from frost injury does not result, as has been supposed, from destruction of the pollen, but from the destruction of the female parts of the flower, such as the pistil and ovaries.

### PLANT BREEDING

The qualities which go to make ideal plants of any kind, in most instances, are high quality, desirable size, shape and color, hardiness, drouth resistance, climatic endurance, and disease resistance. Many different kinds of fruits and plants being grown throughout the state, and tested on the Horticultural grounds, are satisfactory in a number of ways, but lack some single factor

like resistance to cold, late blooming, high quality or color, shipping quality, etc., and are therefore, unsatisfactory for commercial purposes.

The Department of Horticulture, by cross-breeding and selecting plants having the characteristics desired, is attempting to eliminate undesirable factors of fruits, nuts, and vegetables, and to combine the most desirable factors. Considerable progress is being made along this line with certain kinds of fruits and vegetables, report of which will be made later.

## DISEASES OF PLANTS

### A SERIOUS NEW DISEASE THREATENS COTTON

A serious blight of cotton was discovered by Dr. Elliott in West Central Arkansas in June, 1920, doing so much damage in some fields that cowpeas or soy beans were planted in the spots where the cotton had been killed out. Records showed that an outbreak of the same disease had occurred in the same region, along the Arkansas and Petit Jean Rivers, in August, 1915, but the trouble was not then distinguished from some of the well known diseases. Light brown spots with red-brown border appear first on the leaves, then, if the weather continues wet, on the stems at the base of the leaves. The stem spots may kill the plants. If the attack comes later in the season, the bolls become spotted and badly rotted. The spots have the same appearance on all parts of the plant. (See Figs. 33 and 34). In the cases on record, the disease has been destructive only during the prolonged wet spell, and the disease is not known to occur except in West Central Arkansas. In 1921, it was found that the disease occurred only in fields or parts of fields that had been in cotton the previous year. In some cases it was possible to tell, from diseased plants, which part of a field had been in cotton and which in some other crop the previous year. This indicates that the disease can be controlled by crop rotation. The disease, which is caused by a fungus known as *Ascochyta gossypii*, is fully described in Arkansas Technical Bulletin 178.

### COTTON WILT CAUSES HEAVY LOSSES

Cotton wilt is becoming more serious from year to year and is appearing in new fields. A very important fact relating to the spread of this disease was discovered during the past year, when it was demonstrated by Dr. Elliott and Mr. Crawford that the fungus causing the wilt can be carried in seed from wilted plants. (See Fig. 33.) This fact accounts for the general distribution of the disease, and, when known, should lead to the rejection of badly infected fields as a source of seed. Wilt resistant varieties of cotton are being selected and developed for planting on fields

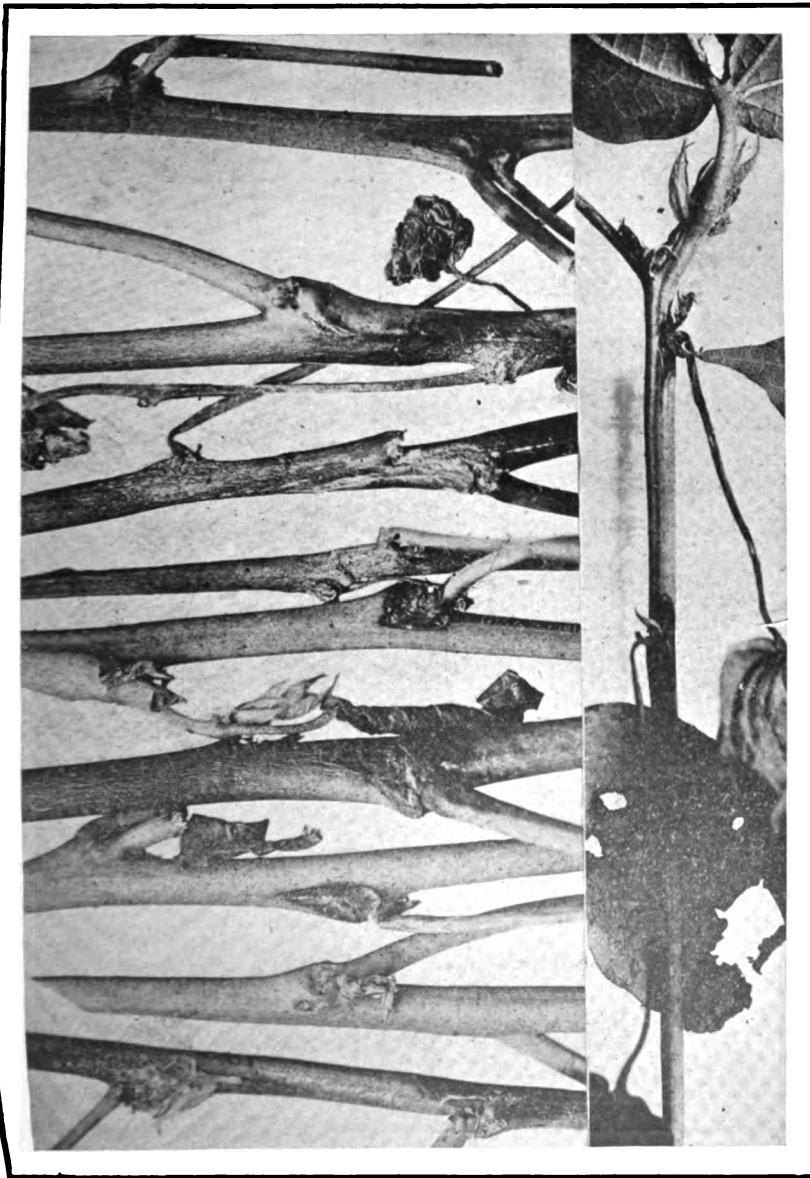


Figure 33. Typical stem lesions of the *Ascochyta* disease of cotton. The lowest stalk shows the shredding in old lesions; the stalk above shows as beginning lesion. All are natural infections. Plant at right shows typical blighted plant when 1921 epidemic was at its height.

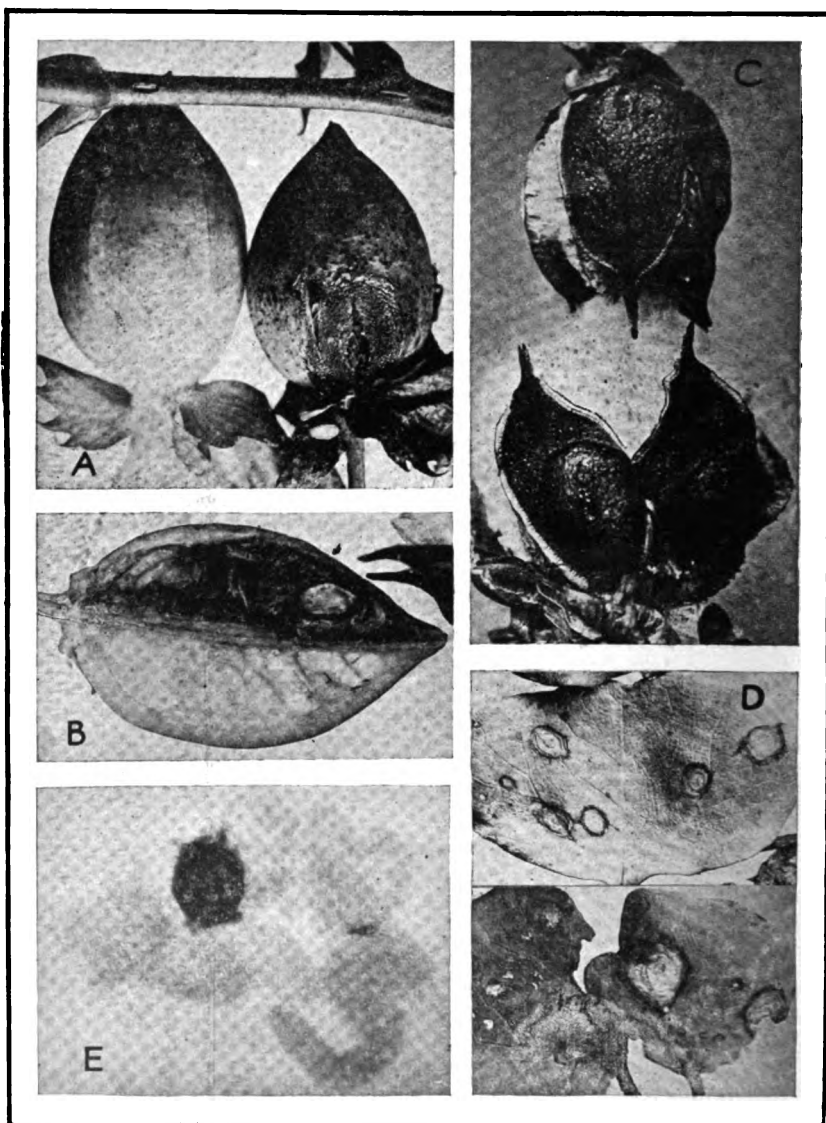


Figure 34. A. Uninfected wounds on stem and boll and infected wound on boll (right).

B. Boll infected and rotted internally.

C. Badly infected boll. D. Ascochyta spots on leaves.

E. Pycnidium of Ascochyta with exuding spores.

already so heavily infected with wilt that the growing of the standard varieties is becoming unprofitable.

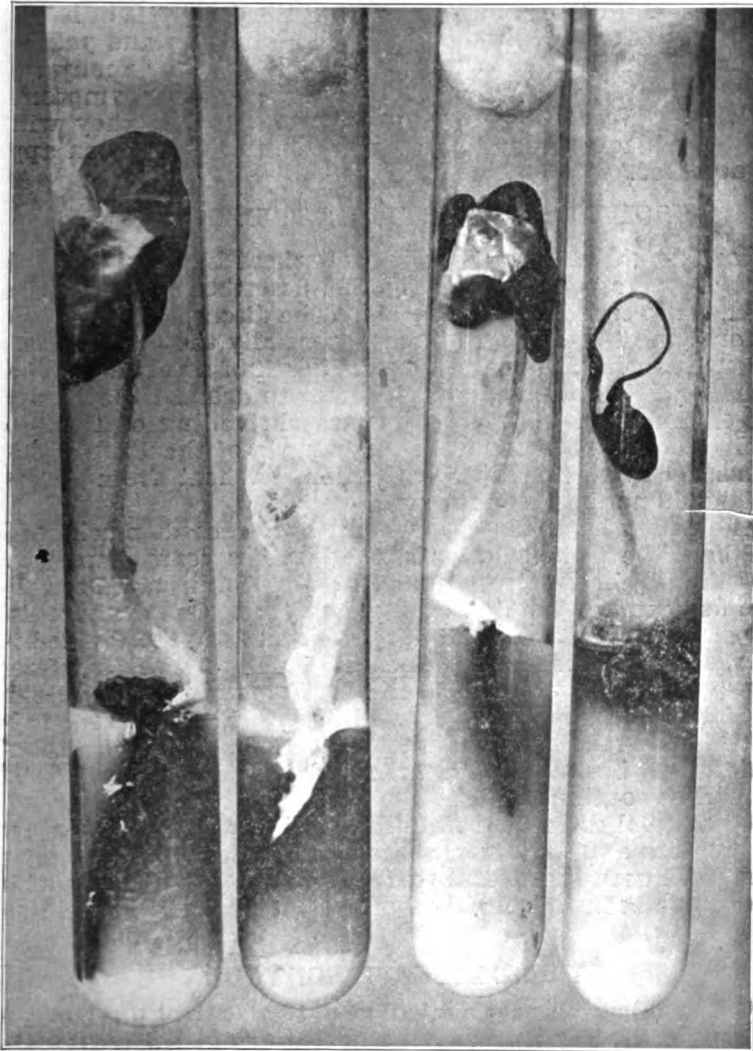


Figure 35. Wilt fungus isolated from cotton seed, 2nd tube from the right shows seedling killed by wilt fungus.

### CORN ROOT-ROT

A bacterial root-rot of corn, which has been found to cause

as high as 30 per cent damage in some instances, has been found in Mississippi and Saline Counties. Work on this disease is being continued with the hope of finding some practical means of combatting it. H. R. Rosen has proven that the disease is of bacterial origin. Symptoms of the disease are: a stunting and yellowing of affected plants, followed by death; or the plants may rot at the lower nodes and fall over before showing other symptoms of the disease. When the lower nodes are cut open they will be found to be blackened and decayed. All varieties of corn appear to be attacked.

### SOME IMPORTANT WHEAT DISEASES

Considerable loss in the yield of wheat has been caused in Northwest Arkansas by glume blotch, described by H. R. Rosen in Arkansas Technical Bulletin 175. The disease causes a brown discoloration of the wheat glumes, especially the outer ones. It attacks the rachis and may cause the death of a part of the head, although this is not common. It seems to exhaust the food material of the plant and thereby cause shrivelling of the grain. The disease has been found in other parts of the United States but has received very little attention. Wheat from diseased fields should not be saved for seed.

Another wheat disease which has caused much alarm throughout the United States in the last few years, namely, the "Australian Take-All," was found by Mr. Rosen and Dr. Elliott in two fields in Washington County last year. One of these fields was secured for experimental purposes and has been divided into plots receiving different treatments. Some of these treatments gave very gratifying results. The best plot promises a yield of from 25 to 30 bushels to the acre with very little apparent injury from the Take-All disease, while the untreated plot will probably not yield five bushels to the acre and is badly diseased. This work will be continued.

A bacterial disease apparently capable of attacking a great many grasses and cereals has been the subject of study on the part of Mr. Rosen for several years. The cause and effects of this disease have been thoroughly worked out and will be published soon.

### APPLE DISEASE CONTROL

The results of disease control even in a year of no crop, were well demonstrated by the spraying operations of last year. Only the scab sprays were applied, but these gave very effective control of scab and held the foliage well throughout the season, in marked contrast to trees left as checks and to unsprayed orchards in the region. Scab was particularly severe, due to weather conditions, and unsprayed trees of susceptible varieties in many cases lost all their leaves early in the summer. The

effect of this injury was very apparent on the trees in the experimental orchard left unsprayed last year. Only one of the twelve check trees had more than a very few blossoms this spring, and this one tree, which bloomed heavily, has since blown down, the bloom apparently being due to injury to the trunk and roots. The sprayed part of the orchard gave a very satisfactory bloom. Comparable results are apparent throughout Northwest Arkansas, emphasizing the necessity of disease control regardless of the fruit prospects of any one season.

### TOMATO WILT SERIOUS

Tomato wilt is becoming an increasingly dangerous menace to the canning industry of Arkansas and the need for successful wilt resistant varieties more pressing. In a large field test near Farmington, the varieties tested did not give results which would appear to make them dependable for commercial planting on badly diseased soil. Two of the newer selections grown on the wilt plot at the Experiment Station showed greater resistance and will be given a field trial this year. The frequent occurrence of wilt in fields of tomatoes grown from seed on virgin soil led to experiments by Dr. Elliott and Mr. Crawford which have demonstrated that the tomato wilt fungus (*Fusarium lycopersici*) is carried on seed from wilt-infected plants. This fact makes easy the explanation of the rapid spread of the disease in regions new to tomato growing, and makes the source of the seed an important factor in the permanent success of the industry.

### SWEET POTATO MOSIAC WIDESPREAD

Sweet potato mosiac has been found in all parts of the state since its discovery and its description by Mr. Rosen in Arkansas Bulletin 167. While experiments have not shown that the disease is easily passed from one plant to another, experience with other mosiac diseases makes it advisable to recommend that plants showing this disease be destroyed as soon as found.

A mosaic disease of clovers and cowpeas is common and serious. In some cases cowpeas are severely injured and the yield of seed much reduced. Investigations by Dr. Elliott have shown that the disease is perennial on sweet clover and is very easily spread from plant to plant. It does not appear to be carried in cowpea seed, but was found to carry over in seed from infected horse beans and bur clover. The importance of the disease warrants further study as to its origin and means of control.

### OTHER DISEASES

More or less investigation has been made of other diseases as they have occurred from time to time. A serious outbreak of alfalfa anthracnose along the Mississippi River was investigated



by Mr. Crawford in the fall of 1921. The disease again put in its appearance in the spring of 1922.

Seed treatment of Irish potatoes has given no positive results in the control of scab in four years' work at the Experiment Station. Results in other parts of the state cannot be predicted from this work since the results may differ with every type of soil.

Greenhouse space for control work is the crying need in plant disease investigations.

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#### AGRICULTURAL CHEMISTRY

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1. A Biological Study of the Nutritive Value of the Velvet Bean.
2. Magnesium Nutrition of Plants.
3. (New). The Relative Efficiency, as Determined by Biological Analysis of the Vitamins, Proteins, and Amino-Acid Values of Certain Forage Crops for Growth and Reproduction.

##### HATCH AND STATE FUND PROJECTS

1. (New.) Calcium Chloride as a Mineral Supplement. Its Use in Cotton Seed Meal.
2. Composition and Distribution of Limestones in Arkansas.
3. Protein, Mineral and Vitamin Deficiencies of Certain Practical Rations.
4. Protein Metabolism Studies with Pigs.

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1. Labor Requirements for Various Crops.
2. A Study of Lease Contracts in Arkansas, and the Share Between Landlord and Tenant.
3. A Study of Retail Costs of Farm Supplies and Their Relation to Farm Profits.
4. A Study of Factors Affecting Marketing of Farm Products in Arkansas.

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1. A Survey of Farm Machinery Conditions in Arkansas, Including Types of Machinery Used.
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2. The Availability of Acid Phosphate in Acid Soils.
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**HATCH AND STATE FUNDS PROJECTS**

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7. Seed Treatment of Cereals.
8. Control of Apple Diseases.
9. The Control of Bacterial Blight (Angular Leaf Spot) of Cotton.
10. The Selection of Wilt Resistant Strains of Cotton for Arkansas.

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**UNIVERSITY OF ARKANSAS**  
**COLLEGE OF AGRICULTURE**  
**Agricultural Experiment Station**

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**THE STRAWBERRY TIGER MOTH**

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**BULLETIN NO. 183**

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**FAYETTEVILLE, ARKANSAS**  
**JANUARY, 1923**

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## THE STRAWBERRY TIGER MOTH

### *Haploa reversa* Stretch

W. J. BAERG

In the spring of 1920 some striped caterpillars were reported as injuring strawberry foliage in the neighborhood of De Queen, Arkansas. Later these caterpillars were found fairly numerous in strawberry beds near Johnsons. At the same time these insects were found feeding on the buds of apple in a small experimental orchard belonging to the Experiment Station. The caterpillars were reared and the moths were identified as *Haploa reversa* Stretch.

In general appearance the larva or caterpillar is dark brown with a reddish stripe along the middle of the back and one or two light yellow stripes, broken by numerous bands, along the sides. The caterpillars are perhaps most commonly seen on apple trees, early in the spring when the buds have begun to separate. They continue to feed on apple for several weeks and at this time they have been mistaken for tent caterpillars. The larvae are seen commonly also on strawberry at the time when the spring growth has well started. In some seasons they are so numerous as to destroy a considerable portion of the foliage.

The moths have a wing expanse of about two inches. Some of them are practically pure white; but usually the majority of them have on the front wing a pattern of black bands on a white background. The moths can be seen flying about during the latter part of May and during the month of June.

### THE COMMON NAME

The caterpillar was apparently first recorded as injurious to the pear tree by Le Baron in 1870. In this report it is incorrectly identified and called "Tent Caterpillar of the Forest". Later, in 1871, Le Baron again refers to this species and calls it the Callimorpha Pear Caterpillar. In the same year C. V. Riley reports this caterpillar from Missouri and calls it the "Blue Spangled Peach Worm". Recently, 1920, Garman of Kentucky in a circular describing the injury caused to apple buds, obviously by the same species of caterpillar, selects for the title of the paper, "A Destructive Bud-Worm of Apple Trees".

The name used by Le Baron is somewhat objectionable because it includes the name of the genus. The name of the genus is likely to be changed, and as a matter of fact has been changed in this case. The name used by C. V. Riley is not very satisfactory because of its length, and furthermore, peach as a host plant is certainly of secondary importance. The name suggested by Garman is too long and besides is misleading. The larvae

are primarily leaf feeders. Since they appear very early in the spring, when the apple buds are just separating, they feed on the buds at this time. As soon as the leaves have unfolded they feed readily on these. Likewise the young larvae appearing in June feed on the leaves. On strawberry the caterpillars feed entirely on the leaves.

Since there are other tiger moth larvae feeding on apple and since none have been reported from strawberry, the name Strawberry Tiger Moth is herewith proposed. As already indicated the caterpillars feed as readily on strawberry as they do on apple. The name is based on the adult stage of the insect, rather than on the larva in accordance with a principle often followed in Economic Entomology. This is to base the common name on whatever form of the insect is most conspicuous. The adult moth with its striking wing pattern and flying by day is more likely to attract attention than the relatively dull-colored larva.

### HISTORICAL

While the insect was well known as early as 1871 when it was first reported by Le Baron, it was not described as a distinct species, *reversa*, by Stretch until 1885. At that time this species along with related forms was still under the European genus, *Callimorpha*. A few years later when J. B. Smith prepared a monograph on this genus, Butler of the British Museum suggested that the American species should be separated from the European and he proposed the name *Haploa* Hubner. The character upon which he bases his suggestion is the fusion of the veins radius and subcosta in the hind wing. In the American species the fused portion extends over one fifth of the length of the discal cell; in the European species the fused portion is much shorter.

Riley in the paper referred to above uses as the specific name *Callimorpha fulvicosta* Clem.; while Le Baron calls it *C. lecontei* and later writers such as Saunders combine the two and consider *fulvicosta* a variety.

This species, known as *Haploa reversa* Stretch in this paper (probably no one can tell at this time what it will be called in the future) has been, together with seven or eight related forms, a fertile field for Species Makers. Of *H. reversa* Stretch alone J. B. Smith makes three species: *contigua*, *lecontei*, and *suffusa* n. sp. Of the group (*Haploa*) he makes ten species. Nine of them are given in his monograph dated 1887 and another, known as *triangularis*, is added later. Smith bases all of his species mostly on the variations of the color pattern on the wings.

Dyar recognized early that many of these species deserved no such rank. In 1896 he listed six species. In a later paper he considers that there are but five species. The species that he

recognizes are: *clymene*, *lecontei*, *colona*, *confusa*, and *contigua*. *H. reversa* he includes under *colona*. An objection may be raised here because the *reversa* as originally described has white hind wings while *colona* has orange or ochre-yellow hind wings. While this is not an attempt to prove a species valid on such an unstable character; yet *reversa*, be it a variety, or race, as it occurs in the Ozark region differs strikingly from *colona* which typically has orange-colored hind wings.

Garman in his paper on "A Destructive Bud-Worm on Apple" considers the moth as "typical of *lecontei*". *Lecontei* was originally described by Guerin, and since the description is accompanied by a colored illustration there remains no doubt as to what particular form he described. His figure is reproduced in Fig. 1. That Mr. Garman is really dealing with *reversa* is

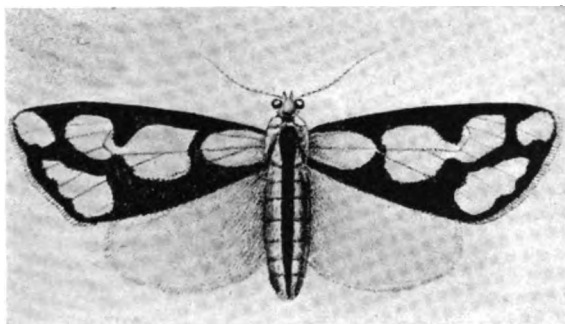


Fig. 1. A copy of the original figure of *Haploa lecontei* made by Guerin Meneville.

shown by the figure in his own paper. The adult moth lettered A in figure 5 of his paper corresponds very well to the original description of *reversa*. By comparing the figure from Guerin, Fig. 1, with the banded forms on Plate I, it is seen that *lecontei* and *reversa* differ very markedly in the color pattern of the front wing.

Marlatt in a paper entitled: "The early stages of three moths", describes a species of *Haploa* which he names *suffusa* Smith. The moth illustrated in his drawing is almost exactly like figure 8 on Plate II. From this it will be seen that his form agrees with *reversa* in every particular except the angle or break in the main diagonal band of the wing pattern. The so-called *suffusa* occurs in the neighborhood of Ithaca and here exhibits the same sort of diagonal band. However, specimens in the Cornell Collection coming from Douglas County, Kansas do not have the angle in the band and agree in every way with *reversa*.

All this discussion is not for the purpose of establishing the soundness of this or any other species of *Haploa*. Neither is it an attempt to straighten out the confusion that exists in regard to the various descriptions and proposed names. It is largely to state clearly the reason why I call the species concerned in this paper *reversa*, and to show as definitely as possible, just what form, be it species, race, strain, or variety, I am considering. It is to show also, in part at least, what relation *reversa* bears to the economic literature already published on this species.

### STUDY OF SPECIFIC CHARACTERS

Since there is this confusion regarding the various species of *Haploa* it seemed desirable to make a study of such external morphological characters as are generally used in taxonomy. The specimens used in this study were collected as follows: *reversa* from Fayetteville, Arkansas; *clymene* from Ithaca, New York; *colona* from Ithaca, New York; *lecontei* from Montana; *contigua* from Otto, New York; *suffusa* from Douglas Co., Kansas; *confusa* from Ithaca, New York.

**Wing Venation.**—Sir George F. Hampson uses as a generic character for *Haploa* the presence of an accessory cell in the fore wing. On Plate III are illustrated a number of wings of *H. reversa* showing the venation in the region of the accessory cell. It may be seen from these drawings that the accessory cell is not always present in *reversa*. In some instances it is present in one wing and absent in the other of the same individual. The accessory cell may be stalked and it may be otherwise. It may be broken up into two or three cells. In the wings where it is wanting it has disappeared either by the coalescence of R2 with R3 and R4 with R5, or because of a failure of R2+3 and R4+5 to unite so as to form the cell. (Plate III, figs. 7 and 16.)

In a general way the same variation, tho not quite so wide, has been found in the wings of the other species: *clymene*, *suffusa*, *confusa*, and *contigua*.

So far as wing venation is concerned all these species might very well be grouped under one species. The different forms might then be considered color varieties or geographical races.

There is another variation in the venation that might be mentioned. The vein R3 that splits up near the margin of the wing into first and second R3 usually arises from R4 somewhere near the accessory cell. In a few forms it arises directly from the cell and in some forms it arises apparently from R3. This is probably of little significance and deserves no more than passing notice.

**Male Genitalia.**—The form or shape of the male claspers\*

\*These are perhaps more appropriately known as valve or harpé.

has come to be regarded as a rather reliable character in determining species. Many lepidopterists consider this character rather more dependable, and subject to less variation than the wing venation. J. B. Smith while relying mainly on the color pattern of the wings bases his numerous species in part on the form of the male claspers. Dyar has found that these likewise vary considerably and that all the different species or shapes illustrated by Smith can be found in a single species. Dyar demonstrates this with illustrations of specimens of *fulvicosta*.

After examining the genitalia of 16 males of *reversa* and a number of each of the following species: *clymene*, *colona*, *lecontei*, *contigua*, *fulvicosta*, and *confusa*; I find that the claspers in *reversa* vary more than those of all the other species taken together, and considerably more than is shown in the illustration of Dyar (See Plate IV, figs. 2 and 16).

These drawings represent a lateral view of the left clasper. The lateral view was chosen in preference to the inside, or mesal, (as Dyar has done) because in this way the claspers could be examined without mutilating the specimens. All that was needed was to remove some of the hairs and scales covering the claspers. The drawings are not exactly to scale, but they are all approximately 16 times the natural size. The difference in the size of the drawings is intended to show, not that the claspers vary by just that much, but that they vary considerably in size as well as in shape.

Thus the two more important external taxonomic characters have been eliminated as not reliable. Color characters of the thorax, abdomen, and palpi have apparently all gradations from orange to white. Other markings show similar variations. The pattern on the forewings is in a way definite; but there is some evidence that this pattern is constant only for a particular locality. It has been found that one species occurring in several localities may often exhibit a different pattern in each of the localities. The *suffusa* of Ithaca, New York varies considerably from that found in Douglas County, Kansas.

Among the individuals found in one locality the pattern is fairly constant for the particular locality as has been observed by several workers. Thus at Fayetteville, Arkansas *reversa* occurs in two forms, one having the banded fore wing and the other having the white fore wing. The forms with the banded pattern are in some seasons about twice as numerous as are the white forms. Gradations between the two occur but are not very common. A few very pale banded forms have been taken, and so have a few white forms with a trace of a band along the costal margin of the wing. It may be added here that Garman has found a form that has a trace of a band along the outer margin of the wing.

With regard to the color pattern of the wings there is this to be said. Within a particular local form, be it species or variety, the wing pattern does not vary appreciably as to its form. It may vary in its intensity, or it may be practically wanting. If the pattern is present it has the same outline in all the forms of that locality. In some instances such a locality may be rather small, and another one be found less than a mile away, as reported by Mason. This seems all the more inexplicable because of the fact that no such regularity can be found in the wing venation or in the shape of the male claspers.

There is another difficulty. Several of the forms of *Haploa* have associated with them a white form. The latter cannot be determined except by the banded form occurring in the same vicinity. Since two distinct forms may occur within a mile of each other there is no safe method of determining the white ones except by rearing from the banded ones.

### COLOR PATTERN AS A SPECIFIC CHARACTER IN OTHER INSECTS

Many of the moths and butterflies were originally described on the basis of color pattern; but later the structural characters have been studied, especially the genitalia which are usually found to be distinguishing and reliable. Exceptions to this are the genus *Argymis* (Silver Spots) and *Eurymus* (Sulfurs) where structural characters that will distinguish all these species have not as yet been found. Dr. W. T. M. Forbes says that in all cases where such characters seemingly cannot be found, he is suspicious of the validity of the species. In the genera named above it seems that too many species have been described.

In the Pentatomidæ (Heteroptera) is a case, *Perillus bi-oculatus*, worthy of note. Two forms considered as two species because of their strikingly different color pattern when reared by Harry Knight turned out to be one species. The difference in color pattern was solely due to different conditions of moisture and temperature prevailing during the time of development.

### THE LARVA AS A BASIS FOR DETERMINING THE SPECIES

It has been suggested by Dyar that the mature larva may furnish a clue. He adds that so far this has not been substantiated. However, this may be due to the fact that all larval studies so far have dealt with a very small number of individuals, usually one or two. Judging from the description of the larva of *elymene*, said to be light yellow, this larva would offer a good character, if the description were reliable. Apparently it is not. Dr. W. T. M. Forbes says that such larvæ of *elymene* as have come under his observation were lighter than for instance *reversa*, but by no means light yellow.

Regarding the larvæ of the various species Dyar said in 1896

that of only two species are the larvæ definitely known. These two species are *reversa* Stretch and *confusa* Lyman. In a later paper (1902) Dyar presents a brief resumé of what is known of the various species of *Haploa* and it appears from this that nothing has been added since 1896.

It is to be regretted that in the few instances where the larvæ and adults have been studied, no adequate figures have been published. The descriptions are brief and refer mainly to the general color and to the more conspicuous stripes.

Marlatt in his study of *suffusa* Smith figures the larva. While the reproductions are too small to allow for any definite conclusions; yet if we assume that the "middle segment" is the fourth or fifth abdominal segment; the larva he studied differs markedly from *reversa*. Groups of setæ III and IV are apparently wanting in *suffusa*.

Garman in his recent paper figures the larva, the setæ arrangement in his drawing agrees essentially with that of *reversa* (Plate IV, figs. 17-20), and leaves no doubt that the two are alike and the same species.

An unusual feature regarding the habits of the larvæ of the various species and varieties lies in the choice of the food plant exhibited by the same species in different localities. Thus the Blue Spangled Peach Worm of Riley in Missouri fed on peach; the Pear Caterpillar of Le Baron fed on pear; *H. suffusa* Smith of Marlatt fed on ash. Smith records *suffusa* feeding on spearmint in New Jersey. Lyman in Minnesota found *contigua* feeding principally on blackberry. He considered the insect identical with the pear caterpillar. Garman records "*lecontei*", which is obviously *reversa*, as feeding chiefly on apple buds. In the Ozark region I have found *reversa* feeding on the buds and leaves of apple and on the leaves of strawberry. Although peach trees were conveniently near by the apple, the larvæ have not been seen feeding on the peach.

## LIFE HISTORY

**The Egg.**—So far as the records show the eggs and the young larvæ have previously been observed only by Marlatt.

In the insectary the eggs were first observed on June 2 (1921). One female laid one mass consisting of 240 eggs, another female laid two masses consisting of 106 and 70 eggs respectively. The eggs are of a light yellow color. From a surface view they appear quite spherical, from a side view they are seen to be elongate. They measure about .08 mm. in length and .07 mm. in diameter. Under low power the surface of the egg appears entirely smooth; under high power and strong light it is reticulated in the form of fairly regular hexagons. (See fig. 2)



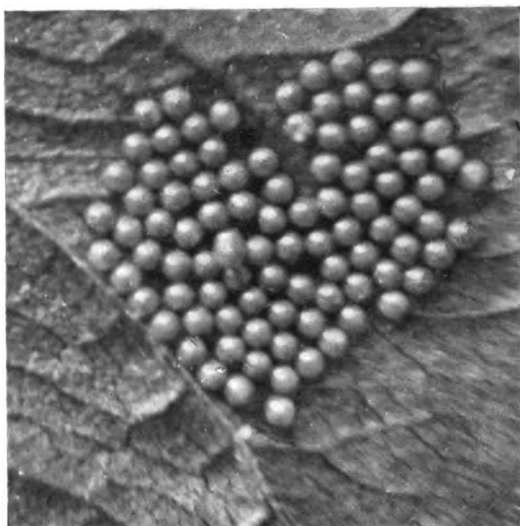


Fig. 2. An egg mass of *Haploa reversa*, magnified about eight times.

**The Larva.**—The eggs laid on June 2 began hatching on June 11, and on the following day practically all the larvæ had emerged. The young larvæ are of a very light greenish color, with a dark brown head and numerous long barbed spines all over the back and sides of the body. The young larvæ just after emergence measure on an average of 1.7 to 2.00 mm. in length. (See fig. 3)

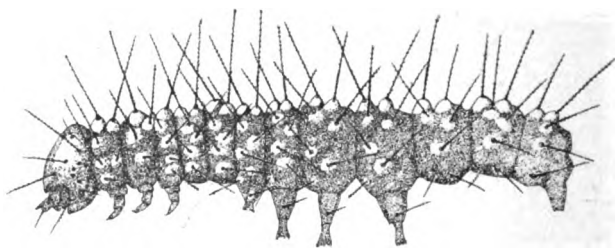


Fig. 3. First stage larva of *Haploa reversa*, magnified about 52 times.

**Rearing of the Larvæ.**—A number of the male and female moths were confined in several types of cages over apple seedlings and strawberry plants. Three or four of the females laid eggs and these hatched in about ten days. The young larvæ began feeding on the foliage, on the under surface of the leaves. They seem to be somewhat gregarious and on some of the leaves

they were so numerous that in a short time they had consumed all but the upper epidermis. When the larvæ were about a week or ten days old they gradually disappeared,—after a few days none could be found. Marlatt in an attempt to rear the larvæ of *suffusa* met with similar results.

In the following year (1922) another attempt was made to rear the larvæ. On June 6 the moths were already flying in considerable numbers. A few females were confined in a cage placed over a small apple seedling, and deposited several egg masses. The eggs hatched in about ten days and the young larvæ began feeding on the underside of the leaves. About 50 of the newly hatched larvæ were placed in each of two battery jars, and provided with some apple foliage. Altho the jars were carefully covered with paper held down with several rubber bands, the larvæ gradually disappeared, till there were but two larvæ left in each of the jars. Late in the fall one of these managed to escape. The three remaining larvæ continued to feed until December 12, when a severe frost killed all the apple foliage. At the time of this writing, they are hiding in some shelter in the jars. They are not more than one-fourth grown. Apparently the apple foliage is not the normal food for the young larvæ. In nature the larvæ that appear in spring are one-half grown or larger. In spite of persistent and repeated searching, the young larvæ have not been located in the orchard. It is not known what they feed on during the summer and fall.

In the Ozark region of Northwest Arkansas the partly grown larvæ (one-half to two-thirds) may be found feeding on the buds of apple as soon as these begin to separate. In 1920 they were first observed on March 10. At about the same time they may be found feeding on the foliage of strawberry. They continue to feed on these plants for a month or more. Then the larvæ hide away and after spinning a flimsy cocoon among some dry leaves, they pupate.

The mature larvæ measure about 30 mm. in length and about 6 mm. in diameter. The back is blackish with a median orange stripe and a lateral yellowish stripe. The latter is a fairly reliable character by which this species may be distinguished from other arctiid larvæ. The body is covered with numerous tubercles each of which bearing a number of black and also white spines. The arrangement of these is shown on Plate IV, figs. 17-20, and Plate V, fig. 1.

**The Pupa.**—Observations made on individuals reared in the insectary indicate that the pupal stage covers from three to four weeks. As already stated, the pupa is covered with a thin flimsy cocoon, constructed among some dry leaves. The pupa is illustrated in fig. 4.

**The Adult.**—The adult moths appeared on May 24 (1921). The moths are easily seen in the field because of the conspicuous wing pattern. They fly about at all hours of the day and apparently feed on the nectar of sweet clover and other plants. The moths occur in two forms; the banded and the white. The white form is known as var. *duplicata*. It may be added here that there is a white form that is found with *colona* which has the hind wings yellow. The white form *fulvicosta* (erroneously placed with *lecontei* by Garman) belongs either with *contigua* or with *militaris*, or possibly with both of them. Another white form known as *vestalis* has not been definitely placed; but likely it belongs with the *confusa* occurring around Ithaca, New York.

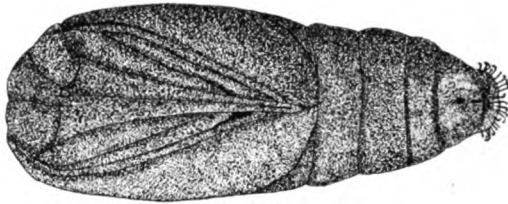


Fig. 4. Pupa of *Haploa reversa*, magnified about 4 times.

Variations of the banded form as well as the white individuals are shown on Plate I. The other species referred to above are shown on Plate II.

### ECONOMIC IMPORTANCE

In the spring of 1920 the larvæ of the Strawberry Tiger Moth were rather common in the strawberry beds near Johnsons, Arkansas. Five or six caterpillars could often be found within a few feet of each other. Reports from De Queen, Arkansas indicated that the caterpillars were sufficiently numerous to attract the attention of the growers. In these instances the larvæ were causing appreciable though not serious injury.

Since on strawberry the caterpillars apparently confine themselves to the leaves and these are rapidly developing at that time, the injury, while it is noticeable does not affect the crop. Yet the number of caterpillars present varies from year to year and it is therefore conceivable that they may a times become sufficiently numerous to lessen the yield.

On apple the caterpillars feed on the buds as soon as these begin to separate, and they are therefore much more injurious; even tho the amount of feeding be comparatively slight, and the caterpillars relatively few in number. In unsprayed orchards it has happened that the caterpillars were fairly numerous and consumed a considerable number of the fruit buds and thus materially lessened the prospects for a crop.

In sprayed orchards, that is those receiving a number of the summer sprays, these caterpillars have so far not been observed. Only in the young orchards that had been given no more than the dormant spray, have I been able to find the caterpillars.

### CONTROL MEASURES

On strawberry beds it will probably not be difficult to apply control measures, nor will it involve any extra expense or effort. The caterpillars appear in the spring, just about the time when control measures for the weevil are being applied. It seems reasonable to think that the dust mixtures containing arsenic in some form will suffice to hold the caterpillars in check in case they appear in sufficient numbers to threaten the yield.

In apple orchards it may be necessary to add some lead arsenate to the regular spring dormant spray mixture. If the caterpillars are very numerous it may be desirable to repeat the poison part of the spray in about ten days. This will practically coincide with the scab spray and will therefore involve very little extra expense and effort, merely the addition of some arsenical to the dilute lime sulfur spray applied for the control of scab.

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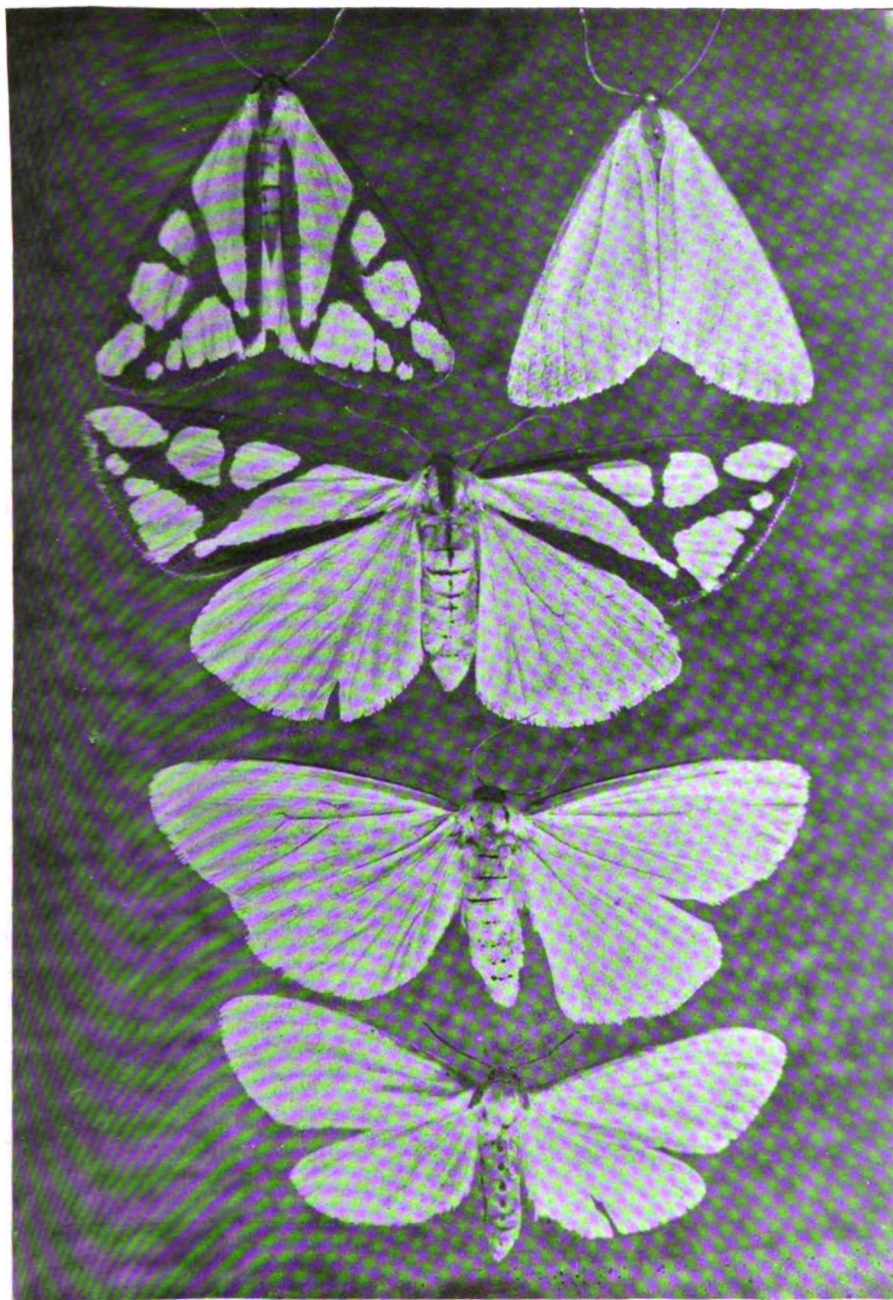


PLATE I.—Upper four moths are forms of *Haploa reversa*. Lowest moth is *Ammalo tenero*, which closely resembles the white forms of *H. reversa*,



PLATE II.—SPECIES OF HAPLOA

- Fig. 1. *H. clymene*, Ithaca, New York.  
 Fig. 2. *H. colona*, Ithaca, New York.  
 Fig. 3. *H. suffusa*, Ithaca, New York.  
 Fig. 4. *H. lecontei*, Montana,  
 Fig. 5. *H. harrisii*.

- Fig. 6. *H. contigua*, Otto, New York.  
 Fig. 7. *H. confusa*, Ithaca, New York.  
 Fig. 8. *H. suffusa*, Kansas.  
 Fig. 9. *H. confusa*, Ithaca, New York.  
 Fig. 10. *H. reversa* var. *duplicata*,  
 Fayetteville, Arkansas.

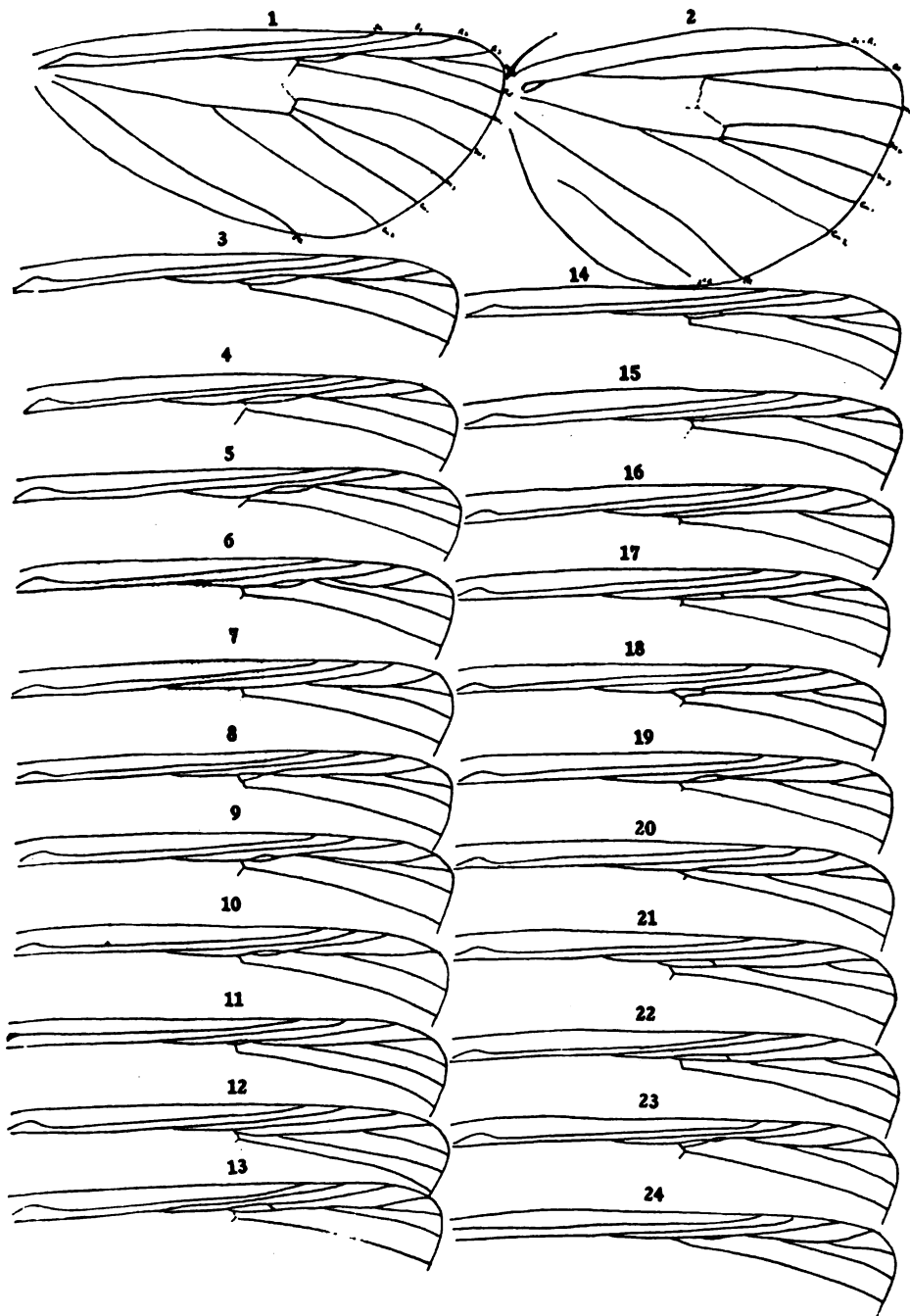


PLATE III.—HAPLOA REVERSA STRETCH. WINGS OF MALES.

Fig. 1. Fore wing, Fig. 2. Hind wing. Figs. 3-24. Fore wings. Odd numbers left wings; even numbers right wings. 3 and 4 are the wings of one individual, 5 and 6 are the wings of one individual, etc. (Note the variation among 4, 6, 7, 8, and 16.)



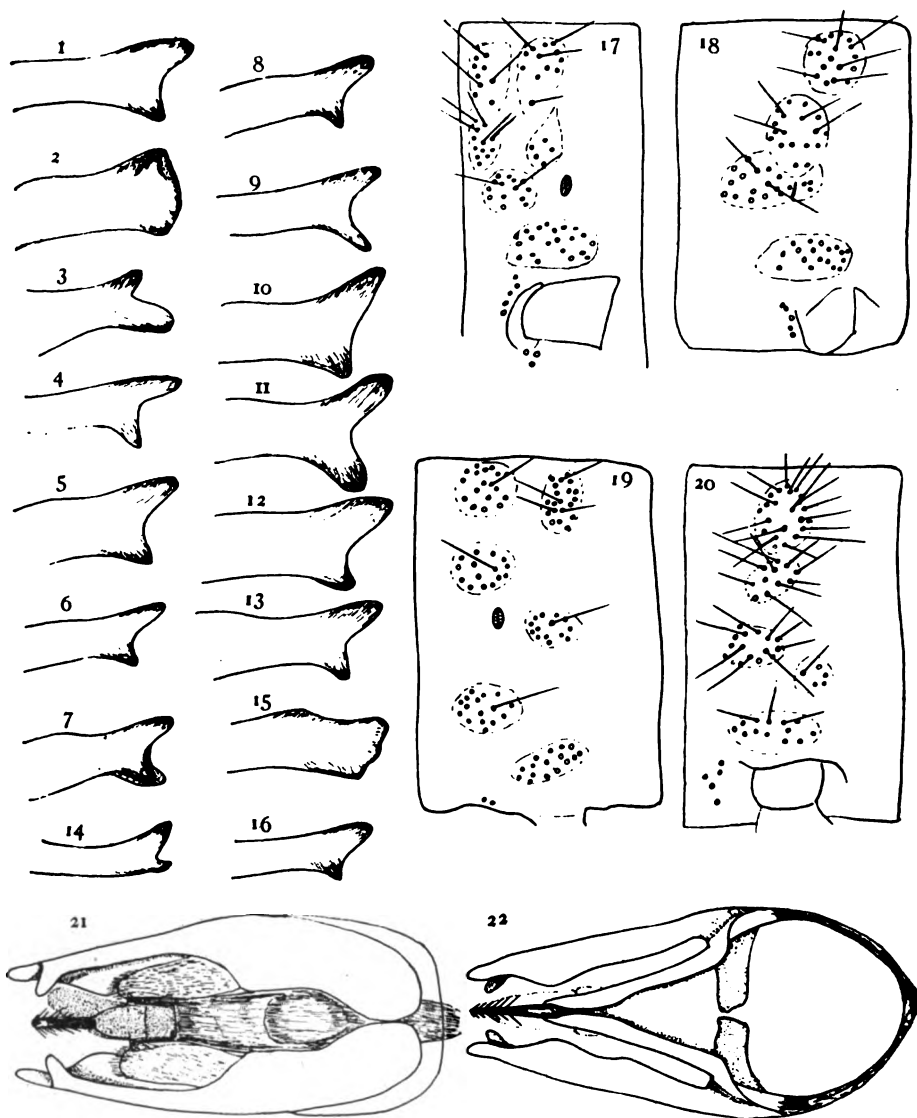


PLATE IV. *Haploa reversa* Stretch. Genitalia of adult males and arrangement of setae in larvae

- Figs. 1-4, 7-9. Claspers of banded forms.  
 Fig. 5. Clasper of pale banded form.  
 Figs. 10-16. Claspers of white forms.  
 Fig. 17. Prothorax of larva, arrangement of setae.  
 Fig. 18. Mesothorax, arrangement of setae.  
 Fig. 19. 4th andominal segment, arrangement of setae.  
 Fig. 20. Metathorax, arrangement of setae.  
 Fig. 21. Genitalia of male, ventral view.  
 Fig. 22. Genitalia of male dorsal view.

Only the black setae are shown in the drawings, the white setae are indicated by small circles.

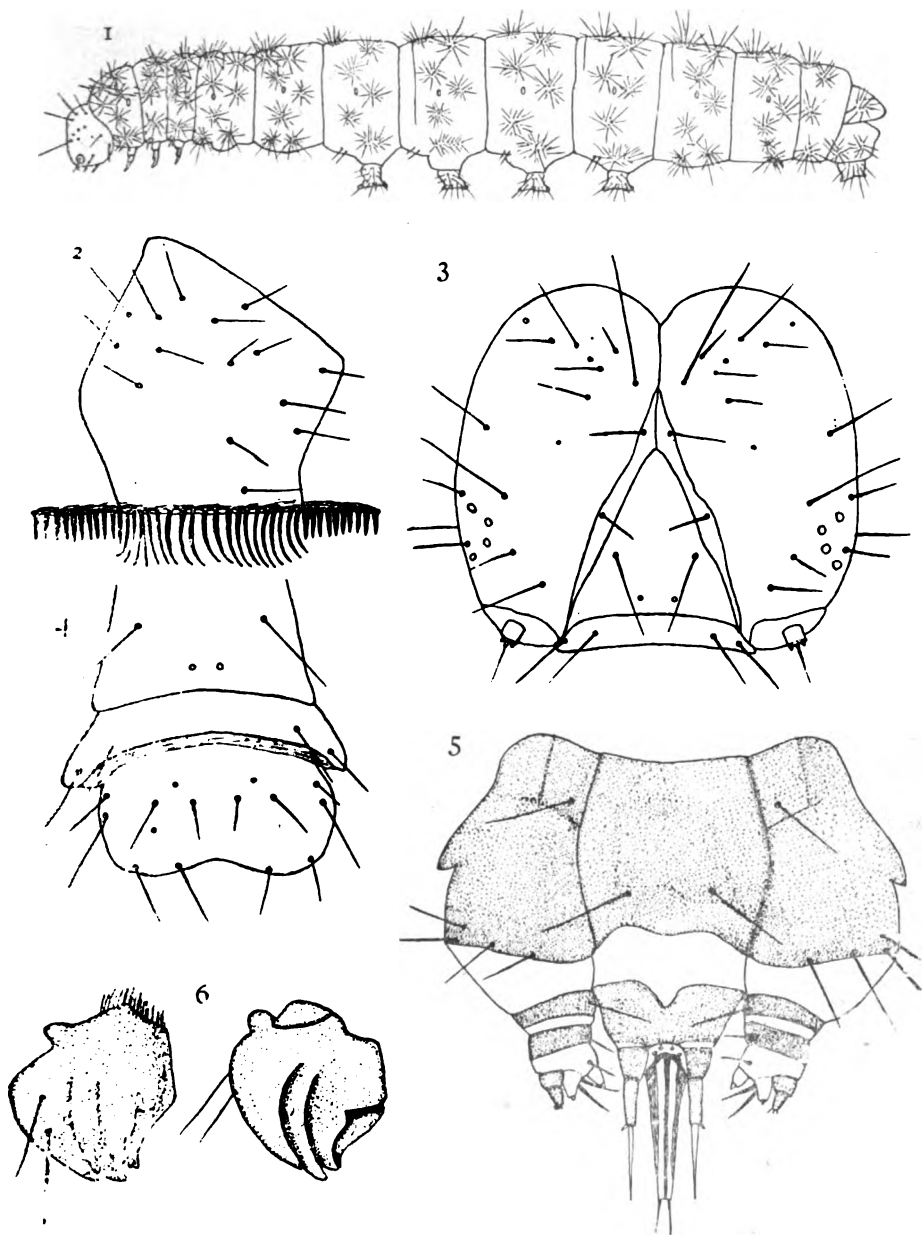


PLATE V.—*Haploa reversa* Stretch. The larva.

- Fig. 1. Mature larva magnified 4.4 times.  
 Fig. 2. Proleg.  
 Fig. 3. Front view of head magnified 23 times.  
 Fig. 4. Labrum magnified 40 times.  
 Fig. 5. Labium and maxillae magnified 40 times.  
 Fig. 6. Inner and outer aspect of mandibles magnified 40 times.



**UNIVERSITY OF ARKANSAS**

**COLLEGE OF AGRICULTURE**

**Agricultural Experiment Station**

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**VITAMINS, HEALTH AND THE  
DAILY DIET**

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**BULLETIN NO. 184**

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**FAYETTEVILLE, ARKANSAS**

**MAY, 1923**

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## PREFACE

### Food and Health From Arkansas Products

Arkansas can produce a large variety of foods which go to make up a well balanced and complete dietary for her people. This state can "feed itself" for health, strength and happiness if we only learn what foods to eat and what proportions are best adapted to the human needs.

**MILK.** This bulletin emphasizes the value of milk. Arkansas needs more dairying. Every rural family should have at least one or two milk cows and the dairy business near our larger towns and cities should be encouraged and protected in every way. At present we produce less than one-third of the milk we should have.

**EGGS.** Eggs are given a high place as a valuable food in these pages. The average number of chickens per farm in Arkansas is only 33 and there are 24,573 farms reporting no chickens whatever. Twice as many poultry per farm would mean better living and health and strength.

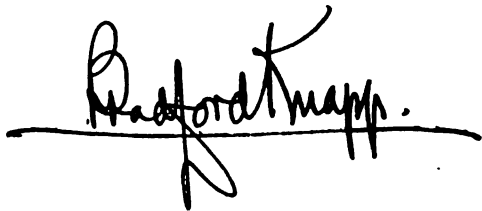
**MEATS.** Most of our meat consumed in larger towns and cities and a large part of that used in some rural sections has to be shipped in. In some rural districts of Arkansas, good lean meat is rarely used as a food while other communities, and particularly city and town families, eat too large a portion of meat in the diet. Arkansas needs to produce and consume wisely the meat necessary for her own uses, well balanced by the other foods suggested in this bulletin.

**FRUITS.** Few states have a greater advantage than does Arkansas in the production of apples, plums, cherries, strawberries, blackberries, dewberries, raspberries, and other fruits. The home orchard and berry patch have an important bearing on the health of our people. Read this bulletin and see how we can plan for health giving fruits.

**CEREALS.** Arkansas produces corn, rice and wheat as her main cereals for human consumption. We have some oats and should grow more. We produce from six to eight million bushels of rice, one of the best and most easily digested foods when eaten in proper combination with other foods as shown in this bulletin. Our average annual production of only a little better than one million bushels of wheat is far below our requirements and we grow only from two-thirds to three-fourths of our needed supply of corn.

**VEGETABLES.** "Leafy vegetables", which this bulletin shows to be so important, can be produced almost the year round in Arkansas. By giving a little attention to a small hot bed and a cold-frame the average family in Arkansas can have leafy vegetables every day in the year. Lettuce, spinach, kale, turnip tops, beet tops, cabbage, sweet potatoes, Irish potatoes, carrots, and many other vegetables grow in Arkansas and can be combined into a year round supply. This bulletin shows the value of vegetables and the necessity of growing them. Particular stress is laid on the tomato, which ought to be grown and used, both fresh and canned, by every family in the state.

In Arkansas we can produce abundantly every food, every vitamin, every protein, every carbohydrate, every necessary fat, and every mineral required for normal, healthy growth, development, and activity. Read the bulletin and learn those things which pay dividends in health, strength and happiness.

A handwritten signature in dark ink, reading "Radford Knapp". The signature is written in a cursive style with a long, sweeping underline that extends to the right.

Director of Experiment Station.

# VITAMINS, HEALTH, AND THE DAILY DIET

By J. W. READ and STELLA PALMER

## INTRODUCTION

**Get your vitamins from the dairy, the garden, the poultry yard, and the orchard.** From these sources they are the best and most cheaply and safely supplied. **Our daily diet largely determines our health,** and the many ailments, the lack of enthusiasm, and the failures of the unwell are usually traceable to faulty food habits.

One difficulty is the deficiency of vitamins. Vitamins add **quality, not quantity, to the diet.** Without them life must cease. In addition to the vitamins, however, a complete diet must contain sufficient amounts of such foods as the starches, sugars, and fats, to furnish enough energy; it must contain proteins of a satisfactory quality, as well as sufficient quantities of a number of mineral elements. To date, three different vitamins, called A, B, and C, have been definitely established. These will be discussed separately. Keep in mind that **all of these vitamins are required for growth in the young and for health and well being in the adult.**

## VITAMINS AND DEFICIENCY DISEASES

**VITAMIN A.** Vitamin A was the first to be given a name, although vitamin B was first discovered. It was called "Fat Soluble A", because of its solubility in fats and its discovery in butter, egg yolk fat, and cod liver oil. Among our ordinary foods the best sources of this vitamin are butter, whole milk, egg yolk, and green leafy vegetables. Carrots and sweet potatoes are good sources, as are also the internal organs, such as the heart, liver, and kidneys, but lean meat is poorly supplied with it. Ordinary cooking does not destroy A to any great extent.

Children cannot grow without this vitamin, and without it they also become very susceptible to various infectious diseases; it is also required for the health and well being of the adult, although smaller amounts of it are needed after maturity has been reached. Its shortage in the diet generally leads to the development of a characteristic eye disease commonly known as ophthalmia, which may cause blindness and also produce other complications that may end in death. This disease is most likely to appear in children in their earlier years of rapid growth. During the World War, a severe outbreak, with the loss of many lives, occurred among the children of Roumania, because the Austrians had driven off all the dairy cows, and their food was limited to corn meal and a soup made from bran and vegetables. In this crisis, a ship-load of cod-liver oil, secured through the



Red Cross, saved thousands of the suffering children. Also, in Vienna and Denmark too, many cures were accomplished by cod-liver oil and whole milk; and, in Denmark, ophthalmia practically disappeared from among infants when the law required butter in the diet, which we are told had consisted chiefly of cooked skim milk, oatmeal gruel, and barley soup. Now the fact is that Denmark has for a long time been famous for the exceedingly fine quality of butter which she produces in very large quantities, but previous to her law requiring butter in the diet, she sold practically all of her butter to outside countries and purchased, mainly from Russia, large amounts of oleomargarine, which the Danish people consumed at home. This substitution of oleomargarine for butter in their diet was responsible for the wide-spread ophthalmia among their children because of the shortage of the A vitamin in the oleomargarines. In Japan, during the food shortage of 1904, many cases were cured by feeding chicken-livers, which are rich in A. It has also been observed that a peculiar night blindness prevails in Northern lumber camps where no butter is served, and bacon furnishes the only fat. This trouble has been attributed to a shortage of the A vitamin, for it quickly disappears when milk or eggs are added to the diet. Night blindness is said to be frequent in Labrador, Newfoundland, and Calcutta, India, also, and the wide-spread infection of eyes in Egypt may be due in part to a lack of the A vitamin. The Indians of Southwestern United States and Northern Mexico also suffer considerably from eye troubles.

Ophthalmia is not the only evil resulting from the lack of the A vitamin. **Certain kidney disorders, certain skin diseases, rickets, diarrhea, pellagra, diminished appetite, imperfect structure of the teeth, and faulty bone formation are likewise associated with its deficiency, as are also such diseases as bronchitis, pneumonia, and tuberculosis, because of the lowered resistance to bacterial infection.** For the proper formation of teeth and bone, the calcium and phosphorus supply must also be sufficient during the entire period of growth. Vitamin A in addition has a marked influence upon the ability to reproduce and successfully nurse the young.

It seems that the body cannot manufacture this vitamin, but it does have the power of storing up more of it than of the other vitamins. Since the storage of vitamin A in the body is so important to the general vigor, stamina, and disease-resisting power of the body, as well as to the successful rearing of the young, it is wise to use liberal quantities of such foods as green vegetables, milk and eggs. Diets which are deficient in vitamin A and calcium are not uncommon, and there is considerable probability of a shortage of the A vitamin in the daily diet.

**VITAMIN B.** Recent investigations indicate that vitamin B, the first to be discovered, may consist really of two substances,

one of which is required for growth and the other to prevent the disease known in man as beri-beri. Everyone needs vitamin B. Without it growth ceases. Its continued lack also produces other weaknesses, such as loss of appetite, a general breakdown of the process of digestion and assimilation, lowered resistance to infection, and improper functioning of the liver, kidneys, spleen, pancreas, and other glands, which, among numerous other complications, may even cause sterility, or prevent successful birth and rearing of the young. Furthermore, if a shortage of it in the diet continues long enough, a paralysis of the nerves, beri-beri, will occur. Two forms of beri-beri are recognized, the dry and the wet. The latter, commonly known as the dropsical form, is brought on by poor proteins accompanied by a shortage of vitamin B. Victims of beri-beri complain of unsteadiness in the legs and knees, numbness and certain disorders of the skin, paralytic symptoms of the nerves, a wasting of muscle tissues, edema (a dropsical condition) of the ankles and face, and very often disorders of the heart, together with other bodily ills. Tuberculosis may end a number of these cases. The mortality is generally high.

It occurs chiefly among the peoples who live largely on polished rice. This disease is most common in Eastern Asia, but Japan, with more than 50,000 patients yearly, is the most afflicted country today. China is less affected than Japan because the Chinese diet contains more vegetables than the Japanese. The following very remarkable occurrence has been reported. In 1910 a ship laden with whole wheat flour was stranded on the coast of Newfoundland. In order to refloat the ship it became necessary to leave behind a considerable quantity of the whole wheat flour. This was consumed by the people in that vicinity, and no cases of beri-beri were reported in this locality for more than one year after the wreck, because the whole wheat contained the germ, which is rich in vitamin B. There were repeated outbreaks in the British Army in the Dardanelles and in Mesopotamia when the soldiers had to live on white bread, canned meat, and jam. Another striking instance during the World War was observed when the German raider, *Kronprinz Wilhelm*, was compelled to seek harbor at New York and allow herself to be interned, because most of her crew had come down with ship beri-beri—a malady believed to be a mixture of both scurvy and beri-beri. The officers of the ship escaped the disease because their daily diet included fresh vegetables and fruits, but the crew had lived on meat, potatoes, and canned goods. Beri-beri is not common in the United States, but some cases have developed. The most notable outbreak was in the jail at Elizabeth, New Jersey, in 1914, where the poor diet of the prisoners consisted largely of white bread. Beri-beri has been produced on a diet of fish, potatoes, lard, bananas, and sugar, with polished rice as the

chief component. If **unpolished** rice is substituted for the polished, beri-beri will not develop. A ration of fresh beef, or bacon or canned meats, polished rice, white bread and potatoes, will likewise cause the disease, as will various other rations similar in their make-up.

In the above paragraph, polished rice has been given as the chief portion of the diet of the peoples where beri-beri is the most common. This does not mean at all that there is anything injurious in polished rice, for there is not. Polished rice is a wholesome and a valuable food, and its starches are 100 per cent digestible. The trouble arises when it constitutes practically the whole of the diet. On the other hand, the **unpolished** rice is more nutritious because the germ and the seed coat of the rice grain are rich in vitamin B, in protein, and in the mineral elements, but these are removed in the process of polishing, and as the Oriental peoples by force of custom demand the polished rice, just so do we require our rice mills to furnish the trade with the polished grain. Manufacturers would provide the unpolished if our people preferred it.

Good sources of vitamin B include milk, eggs, raw and cooked vegetables of all kinds, and the various fruits commonly used as food. Nuts are also valuable sources. Muscle tissue is poor in B, but such organs as the liver and the pancreas are fairly well supplied. White flour is notably deficient in B, because the seed germ in which this vitamin is stored in the cereals is removed in the milling. **Ordinary cooking processes, especially where baking soda is used, are more or less destructive to B.** Hence the necessity of precaution on the part of the housewife to use soda only for leavening purposes in the making of hot breads, and to employ cooking periods of no greater length than those actually required. For example, cabbage may be boiled sufficiently in 20 minutes rather than in from one to three hours, as is frequently done. If proper periods of cooking are carefully observed and waste is prevented by saving most of the water used in cooking, there need be no fear regarding a serious loss of the B vitamin, provided the foods selected are well supplied at the outset. In commercial cooking and canning, where high temperatures and pressures are employed, the destruction of B is probably a more serious matter.

**VITAMIN C.** Our daily diet must be sufficiently supplied with vitamin C in order to promote general well being, as well as to prevent scurvy. This is especially true because our bodies seem to have little or no capacity for storing up this vitamin. Scurvy has been known for centuries. We learn that Vasco da Gama lost 100 men from scurvy out of a crew of 160 on his pioneer voyage to the East Indies by way of the Cape of Good Hope; also, that the armies of the Crusaders suffered from it during the siege of Cairo, in the 13th century; and that Jacques Cartier lost

26 of his crew in the St. Lawrence River during his voyage of 1536, and saved the rest from death by scurvy by using a tea made from pine needles. In 1720, Kramer wrote that scurvy could not be cured by surgery or by medicine. Restricted diets have made this dreadful disease prevalent in every war, and particularly so in our War of 1812 and in the Civil War, in the latter of which there were no less than 30,700 cases, brought on by the use of dried vegetables in winter. At such times numerous cases also break out among the citizens at home. This happened in Europe during the recent war, where severe outbreaks were so frequent on all fronts that special control stations were set up to keep down the disease as much as possible. It is reported that no scurvy occurred among the American soldiers, because canned tomatoes were included in their diet. One notable outbreak occurred at the siege of Kut-el-Amara, when the British and Indian troops were besieged by the Turks from December, 1915, to April, 1916. During this period the diet of the British soldiers consisted of white flour biscuits, canned meats, and fresh meat secured by killing their oxen, horses, and mules. Because of religion, the Indian troops refused the fresh meat and substituted for it a whole barley flour and dried pulse. The outcome was that the Indian soldiers developed scurvy, and the British beri-beri. The whole barley flour, containing the seed germ, protected the Indians from beri-beri, and the fresh meat (eaten rare or raw) prevented an outbreak of scurvy among the British troops. Towards the end of the siege, scurvy practically disappeared when three ounces of green vegetables were given to each man every day,—even though both the British and Indian soldiers were slowly starving to death. It is of especial interest to note that gardeners were transported to grow vegetables in order to avoid future outbreaks.

Scurvy in infants, frequently referred to as Barlow's disease, is confined almost entirely to unnaturally fed children, but it may occur even in breast-fed infants, if the mother's diet is deficient in the C vitamin. Scurvy is not an uncommon disease and appears to be growing more common, probably because of the present practice of feeding more babies on heated milk than formerly. A few years ago the American Society of Child Specialists reported that, out of a total of 356 cases of scurvy in infants, only 10 of these infants had been nursed. This same society points out that 45 per cent of the cases of infantile scurvy are complicated by rickets. Drs. Hess and Unger of New York City report that modified milk mixtures containing malt soup are especially likely to produce scurvy in infants. This results from the use of alkali in the preparation of the malt product, whereby vitamin C is mostly destroyed.

Scurvy usually appears between the 6th and 18th month of the child's life and develops in varying degrees of intensity, but

the more common symptoms are cessation of growth, abnormal color of skin, occasional swelling of upper eyelids, soreness of lower limbs, restlessness, and lack of proper bone development. In adults, some of the more characteristic symptoms are paleness and disorders of the skin, nervousness, pains in the lumbar region, rheumatic sensations in the lower extremities, shortness of breath, swelling in the knee caps, heart weakness, loss of muscle, and a spongy condition of the gums, especially around decayed teeth. In acute cases the teeth may even drop out, and there may be convulsions and delirium. Various complications may cause death, but these are more generally of an infectious character. Scurvy can be cured and prevented in infants by giving the natural juices from such fruits as tomatoes and oranges. In adult cases, it may be cured by other fruits in addition to those mentioned, by raw vegetables, such as cabbage and lettuce, and also by sprouted seeds which develop the C vitamin on sprouting.

The best sources of C are fresh young vegetables, such as cabbage, spinach, water cress, lettuce, onions, the raw juices of turnips (especially the rutabaga, or Swedish turnip), beets, and carrots, and from such fruits as oranges, lemons, tomatoes, and berries. Fruits which are naturally high in acid contain more of vitamin C than do those which are more starchy and richer in sugar. The Irish potato, if it is not overcooked, is a fair source of C. The practice of boiling enough potatoes for two or three meals and cooking them a second time by frying is a mistake. The internal organs, such as the kidney, liver, and pancreas are well supplied. The vitamin C content of cooked potatoes resembles that of apples and bananas, weight for weight, but tomatoes and oranges are from six to eight times richer. It is probably true that the potato, on account of its abundant use in the diet, serves as the chief preventive of scurvy during the winter months. This is particularly true of the working classes. In this country we eat probably twice as many of potatoes as all other vegetables combined. To prevent scurvy, about one pound of potatoes per day is needed in the diet. In the spring of 1916, as has also happened during other periods of potato famine, scurvy broke out in a number of hospitals for the poor, where the potato is the chief source of the C vitamin. These outbreaks have been attributed to the poor crop of potatoes in the fall of 1915. The dependence on the potato as the chief source of vitamin C can mean only that a large number of people are not securing enough of this vitamin during the winter season when fresh fruits and vegetables are scarce, and one should ever keep in mind that it is the too small amount of any vitamin which undermines the health.

Unlike A and B, the C vitamin may be practically destroyed in the ordinary processes of cooking, preserving, and drying by heat. Canned tomatoes, however, and other naturally acid fruits,

furnish an exception because the fruit acids protect the C vitamin to a large extent. The use of the fireless cooker over long periods is more destructive to C than actual boiling for a time. This vitamin is mostly destroyed when cabbage is cooked longer than 20 to 25 minutes. Most vegetables are cooked much longer than is necessary. During the late war an outbreak of scurvy among certain labor camps in France was the result of cooking their limited ration of vegetables from two to three hours instead of 45 minutes. Vitamin C is especially sensitive to baking soda. Neither baking soda nor vinegar should be added to the cooking water. It becomes necessary, therefore, to depend largely upon raw milk and fresh fruits and such vegetables as are commonly eaten raw to provide a good margin of safety with regard to vitamin C. Less of C will be required if the diet is satisfactory in all other respects. Scurvy is not common among adults, but no doubt many people barely escape it.

**RICKETS AND A FOURTH VITAMIN.** The destruction caused by rickets is not commonly understood. It is agreed that probably one-half, or more, of all our children, at some time during their period of most active growth, suffer to a greater or less extent from rickets,—a disease which is peculiar to the bones, although there are generally other manifestations besides faulty bone formation. This disease is our most common nutritional disorder. A deficient diet is responsible for it. It is especially peculiar to young children between the ninth and twenty-fourth months, but during the recent war almost all ages suffered from it. Although primarily a disease of the bones, other weaknesses are linked up with it, such as late and faulty development of the teeth—sometimes even without enamel—weak legs, flabby muscles, a general impairment of digestion and assimilation, nervousness, whining and restlessness, and delayed closing of the skull on top. Also, rickets predisposes to infections of the lungs, such as bronchitis, whooping cough, pneumonia, and tuberculosis, and tends to lower both physical and mental efficiency in later life. Furthermore, rickety children suffer more frequently from adenoids and enlarged tonsils than do normal children. Although rickets is not common among breast-fed infants, it does occur in breast-fed children much more frequently than is generally supposed. It may quickly appear if the mother's diet is limited to cereals, lean meats, and potatoes. Plenty of fresh vegetables, fruits and dairy products in the mother's diet and plenty of outdoor sunlight for the baby will prevent the development of rickets. New cases of rickets appear most frequently in the spring. In a certain poor section in New York City, 90 to 100 per cent of the negro babies are victims of rickets in spite of the fact that nearly all of them are fed at the breast. This condition is caused by the lack of good fats (such as butter) and green vegetables in the diet of the mothers. The negro child in Africa does

not develop rickets because he lives out of doors and is nursed by a mother whose diet is simple, but satisfactory. **Condensed milk, commercial infant foods, and a diet too rich in starches and sugar all pave the way for rickets.** In certain schools in England 80 per cent of the children were found to have rickets, and, following 1917, about 90 per cent of the children born in Austria and Germany suffered from this disease. On the other hand, the children in West Ireland, where dairying is the chief occupation, rarely have rickets, and this disease was also practically unknown among the Icelanders, Eskimos, and Lapps before commerce greatly changed their dietary habits. These peoples formerly consumed large quantities of fats which were rich in the vitamin that protects against rickets, and weaned their children to the same type of diet. The liberal use of leafy vegetables in the Chinese diet prevents rickets among Chinese children.

It appears reasonably certain that rickets is caused by a shortage of a new vitamin, when this shortage occurs jointly with a faulty proportion between the amounts of calcium and phosphorus consumed. A faulty composition of the diet with respect to carbohydrates, fats, and proteins may also aid in the development of rickets. Cod-liver oil is exceedingly rich in this new vitamin and is used to cure or to prevent rickets. This disease may also be prevented or cured by exposure to direct sunlight (not through glass) for 15 to 45 minutes daily, the time depending upon the sensitiveness of the baby's skin to the direct rays, which are first allowed to fall upon the legs, then the arms, and later upon the chest and back in suitable weather. This beneficial influence of light tends to condemn the usual practice of bundling up babies, even during the winter and spring months when rickets is by far the most common. The sunlight remedy is not so satisfactory for colored infants because it is difficult for the light to pass through the dark skin to the tissues underneath.

**PELLAGRA.** Since 1700 pellagra has been known in Northern Italy, where it is even today more prevalent than in any other country. It has appeared in all parts of the world, regardless of climate or race, and people of all ages suffer from the disease, which in many cases comes on so gradually as to be imperceptible. In 1918 there was a severe outbreak of this disease among Turkish war prisoners in Egypt. Our own country has about 200,000 sufferers every year and 10,663 deaths from pellagra were reported during 1915. In the United States this disease usually appears in February and continues until the late fall. The extent to which it occurs in certain sections of the southern states is chiefly the result of a one-crop system of farming, which leads to a restricted diet, particularly during the winter months. Pellagra is not inherited, nor is it contagious, but children of pellagrins are frequently stunted both physically and mentally, and also show other weaknesses. The disease has appeared in nursing

infants as a result of the poor milk produced by the mother on a faulty diet. The most outstanding symptoms of this malady are pronounced weakness and injury to the nervous and circulatory systems, severe digestive disorders, and a characteristic eruption of the skin. The flesh, the strength, and the intellect fade away. Numerous other complications may occur, but whatever may be the specific reason, or reasons, for its onset, there is every evidence for believing that it is brought on by a diet poor in quality, both as regards proteins and the vitamins. Soda biscuits, corn-bread, polished rice, gravy, potatoes, molasses, and fat pork with little or no milk, vegetables, or fruit, make up the common type of diet among pellagrins. Cure or prevention can generally be effected by a proper change in the diet, in which milk, eggs, cheese, green vegetables, fruit, and choice lean meat instead of "sow belly" are well supplied. The disease is from two to three times more common among women than among men.

### THE DIETARY PROPERTIES OF CERTAIN CLASSES AND TYPES OF FOODS

**MINERALS.** About four per cent of our body weight is composed of calcium, phosphorus, potassium, sodium, sulphur, magnesium, chlorine, iron, iodine, silicon, and fluorine. It is just as necessary to furnish these minerals to the body as it is to provide the vitamins and satisfactory proteins. Minerals are required to construct teeth, bone, blood, nerves, and flesh, and to regulate the functions of various body fluids, such as the blood and the digestive juices, as well as to control the normal action of certain special glands in the body. Deficiency in these elements leads to physical debility, pale cheeks, poor blood, rickets, hardening of the arteries, and lack of tone in the muscles, nerves, and eyes. The body is particularly sensitive to a deficiency of any one of the essential mineral elements and may be seriously injured by too small amounts, or may die quickly if the supply is cut off. For example, a lack of iodine causes an enlargement of the thyroid gland, known as goiter, which is common around the Great Lakes, in the upper Missouri and Yellowstone Valleys, and in Eastern Oregon and Washington, because the iodine content of the drinking water and the vegetation is unsatisfactory, since the soils in these sections are especially poor in this element. The common salt of our food furnishes acid for the stomach, and also a small amount of iodine, which is present as an impurity. The normal beating of the heart depends upon the proper amounts of calcium, sodium, and potassium in the blood. Calcium is more often lacking in our daily diet than is any other single element. A child from three to thirteen years of age needs as much calcium per day as two grown men in order to produce sound teeth and bones. Milk and the green leafy vegetables are the best sources of calcium. They



are also rich in phosphorus, an element of no less importance in body building than is calcium. There is, however, only a small amount of iron in milk, but the baby is born with a supply of iron sufficient to last it several months. **Iron is required to make red blood corpuscles. The lack of red blood causes anemia, or paleness of color.** Many young children are anemic because of an insufficient supply of iron. Hence the great importance of such foods as spinach and the yolk of eggs very early in the child's diet. Spinach, of course, must be properly cooked so that a large portion of the iron will not be thrown away in the cooking water. **Iron is always best secured in foods, and not in so-called "tonics" or medicines.**

**WHY PROTEINS DIFFER.** Before 1901, proteins from different sources were thought to have about the same nutritive value, but such a conception was indeed very far from the real truth! Today we know that every protein is composed of about twenty different amino acids, which may be compared to the "building stones" in a wall, no two of which are exactly alike and that, because of differences in composition, some proteins are very poor, some medium, some good, and some are excellent. We have discovered also that the body can not manufacture certain of these "building stones" which are required for growth in the young and for health and vigor in the mature. They are no less important, therefore, than are the vitamins and the essential minerals. A good many of the proteins found in our common foods are either deficient or totally lacking in one or more of these indispensable "building stones", and for this reason they are imperfect. We can surmount this difficulty only by securing a knowledge of the shortcomings of the proteins from various foods so that they can be combined intelligently in order to make the proteins in the diet complete. To illustrate, the proteins from the seeds of our cereals and legumes vary not a little in their composition, but all of them are deficient in some one or more of these absolutely required amino acids, which we have termed "building stones". To make good these deficiencies, we must supplement them with other proteins, such, for example, as the proteins of milk, which will fill out the shortcomings of any diet composed of the ordinary range of food-stuffs. The proteins of meat and eggs are also excellent for supplementing the proteins of seeds, potatoes, and vegetables in general.

**COOKING IN WATER.** Many studies have shown that a large amount of food value is often thrown away in the water used in cooking. This loss will depend largely upon the solubility of the various nutrients in the vegetables or other foods being cooked, and upon the quantities of water which are poured out after the foods have been cooked. Vitamins B and C are soluble in water and may be thrown away in large amounts. Besides

these vitamins, there are other losses in the form of minerals, soluble starches, and sugars. These facts emphasize the nutritive value of soups, especially well made vegetable soups. No less than 70 per cent of the water-soluble substances in potatoes may dissolve in the water in which they are boiled, and this proportion seems to hold true for vegetables in general. The food values lost in this way are more likely to prove serious, of course, when there is only a narrow margin of safety, but the housewife should ever keep these dangers in mind and as far as possible avoid them in all cases. This can best be done by using as little water as is practical for cooking purposes and frequently turning this into soups rather than into the sink.

**MILK.** Milk has no substitute. It has been truly called a protective food. Milk contains proteins excellent in quality, and furnishes, with the exception of iron, all of the necessary mineral elements. Also, milk sugar, unlike ordinary sugars, does not irritate the intestine, but exerts a helpful influence upon digestion in the intestine. Although provided by Nature as a perfect food for the growing young, milk is also very essential for the adult. In order to secure the greatest health and vigor, the average American diet today should include much more milk than it does. Milk contains all of the known vitamins, if the dairy animal receives a ration well supplied with these vitamins. The milk from cows on spring pasture is frequently several times richer in its vitamin content than the milk produced from dry feeds during the winter season. It is very important, however, that we keep in mind that the B and C vitamins—more especially C—are not abundant even in good raw milk, and that pasteurization may destroy C. The animal body does not seem to have the power to make these vitamins for its own use; hence the absolute necessity of furnishing them in the diets of the nursing mother and of the dairy animal. Good leafy hays and silage should be fed abundantly with the more concentrated feeds of the dairy cow during the winter months. At no time should dirty, stale, unwholesome milk be used, or milk from unhealthy animals. Babies are quickly made sick by unclean milk full of dangerous germs, which remain in the intestine and poison the body; and every succeeding attack of this nature injures more and more the future health and physical development of that child.

**PREPARED INFANT FOODS.** Nature has planned that every baby should be nursed by its mother, unless there are very evident reasons for not doing so. Records show that among equal numbers of breast-fed and bottle-fed infants, death calls no less than five times as many from the ranks of the bottle-fed as from the breast-fed. Some investigators even report ten times as many deaths among the bottle-fed. It is better for the health

of both mother and child that the baby be nursed, unless the mother is suffering from tuberculosis or other exhausting diseases, or is absolutely incapable of nursing, which latter rarely happens. If the mother's milk is not sufficient to supply the baby with all the food he needs, the mother should give him as many feedings as possible and then supplement with artificial food. **The nursing mother cannot possibly produce good milk on a faulty diet.** The very best diet for her is one which contains good whole milk in abundance, because milk so plentifully furnishes many of the food substances she must have. Vegetables and fruits should be eaten liberally,—particularly the leafy vegetables. Dr. R. M. Woodbury, Director of Statistical Research, Children's Bureau, U. S. Department of Labor, estimates that out of the 2,400,000 babies born annually in the United States, no less than 210,000 die under one year of age, and that under two years of age diarrhea and inflammation of the intestines alone take a yearly death toll of 46,900. No doubt there are many other thousands who are permanently injured by improper feeding.

When a substitute must be made for mother's milk, pure fresh cow's milk (unless goat's milk is available) is the best, but the milk of no cow should ever be used unless the cow has been shown by actual test to be free from tuberculosis. **Tuberculosis of the intestines is readily transmitted to infants through raw milk; it is not transmitted through properly pasteurized milk.** As a rule commercial pasteurization is not to be trusted. Milk may easily be pasteurized at home by heating it in a double boiler for 30 minutes at a temperature of 140 to 150 degrees Fahrenheit. It should be cooled promptly, after heating, and kept cool until used.

The utmost care should always be taken to keep all litter and dirt out of the milk in every handling. The person who milks should be healthy, clean, and perfectly free from infectious diseases. The bacterial count of milk should preferably not be over ten thousand per cubic centimeter, and no dangerous organisms should be present. None but fresh milk should be given the infant, and never any milk to which preservatives have been<sup>1</sup> added. In cities where the quality of fresh raw milk is not definitely known to the private consumer, certified milk is safer by far. Indeed, raw market milk should never be used unless it is sterilized by boiling. Where pure fresh milk cannot be had, it is the opinion of the Bureau of Public Health, and other expert agencies, that the high-grade dried milks are better than other preparations. The great objection to the use of these dried milks lies in the difficulty of diluting them so as to suit the digestive ability of the infant.

Condensed milk is a food low in fat, protein, and ash, and very high in sugars. When it is diluted so that the sugar content is satisfactory, the protein and mineral percentages are made

entirely too low, and if the protein and mineral values are made satisfactory the sugar content is entirely too high, and such large amounts of sugar bring on nutritional disturbances. Also the calcium or lime compounds of these forms of milk seem to be interfered with in the condensing process. Dr. Lewis Webb Hill of the Harvard University Medical School has classified condensed milk babies into three groups, as follows:

"1. The babies of the first group are of normal weight for their age or grossly overweight. They are round and fat and seem well. On closer examination, however, it is seen that they are pale and their tissues are not firm and solid as they should be. They lack muscle tissue and have in its place fat and water.

"2. The babies of the second group are much emaciated and usually have rickets, if they are over six or seven months of age. These have been fed on a weak dilution of condensed milk over a long period of time. They have just had enough to keep body and soul together, but not much more.

"3. The babies in the third group are neither very thin nor very fat, but are small for their age. They are delicate looking, rather pale and flabby; their hands and feet and bones are small; they may or may not have a moderate degree of rickets. This is perhaps the most common type of condensed milk baby." On the other hand, in the diet of adults these preparations do have their proper place, and the industry is an important one.

S. M. A. It is well understood that young infants cannot utilize as high a percentage of fat in cow's milk as they can in breast milk, because of the differences in composition, which may produce severe nutritional disturbances. After much study and seven years of practical feeding observations, Dr. H. J. Gerstenberger, Medical Director of the Babies' Dispensary and Hospital and Expert in Children's Diseases in the Western Reserve Medical School, has recently placed on the market an artificial food, the composition of which approaches mother's milk. Because the best results are obtained in this way, this product is sold under the name of S. M. A. (Synthetic, Modified, Adapted), only on the order of a physician who is supplied with full directions for its use. It can be obtained in powdered form from the Laboratory Products Company, Cleveland, Ohio. This is not a commercial product, and it should be said that the proceeds from its sale go to the Babies' Dispensary and Hospital for the purpose of promoting study and research relating to the diseases of children.

The frequent practice of using commercial infant foods without the advice of a thoroughly competent physician is certainly to be condemned. To use them as the mainstay of the infant's diet, or merely to follow the directions on the container is dangerous. The chief dangers of these preparations are eliminated when the attending physician definitely knows their com-

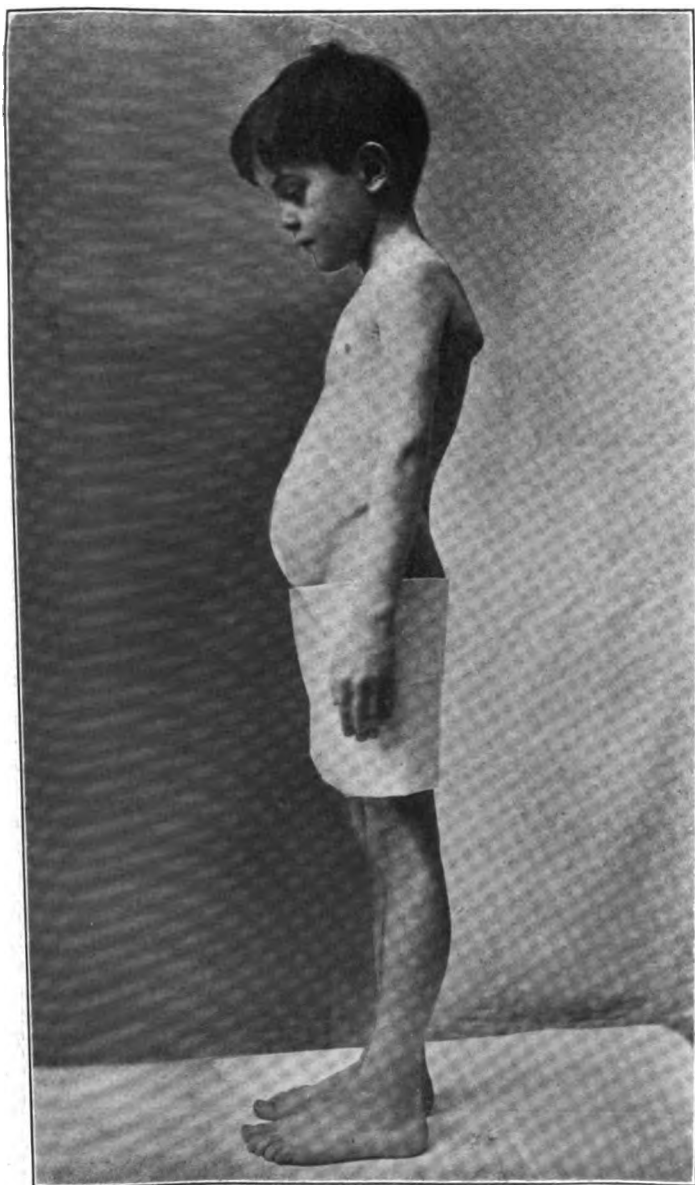
position, and uses them with a specific purpose in mind, in connection with milk as a supplement.

In all cases of artificial feeding, whatever the food used, it is absolutely essential to supplement the diet with orange juice or strained tomato juice (from either raw or canned tomatoes) in order to furnish vitamin C so as to prevent scurvy. This is also good practice, even when pure fresh cow's milk is fed, unless the diet of the cow is well supplied with plenty of green food or properly cured hays, such as alfalfa and clover. Cod-liver oil should also be used in artificial feeding as a routine measure for the prevention of rickets.

**THE LEAFY VEGETABLES.** Practically every family in the land should eat far more green vegetables. The leafy vegetables, such as cabbage, turnip and beet greens, spinach, chard, lettuce, and water cress, are protective foods, and should have a particularly important place in the diet. Their mineral composition is exceedingly valuable. They are particularly rich in iron, and are especially good sources of the vitamins. Every intelligent mother should see to it that her children learn to like them and are regularly supplied with them early in life. Furthermore, like the turnip, beet, and radish, they provide the best correctives for that common and pernicious evil—constipation. Cathartics irritate the intestine and gradually do it damage. They are to be avoided as much as possible.

**OTHER VEGETABLES.** The Irish potato is one of our most important foods for furnishing energy. Its dietary properties resemble those of the whole grains except that it is fairly well supplied with vitamin C, which develops in the grains only when they are sprouted. The potato holds a unique place because it is particularly relished with fats and one seldom tires of it. The sweet potato has essentially the same place in the diet as does the Irish potato, but unlike the Irish potato it is well supplied with vitamin A. Carrots are rich in both the A and B vitamins. The juice of the rutabaga, or Swedish turnip, is especially rich in vitamin C, and like orange or tomato juice is suitable for infant feeding. Turnips and beets contain fair amounts of the A vitamin, and beets and onions are very good sources of vitamin B. As a class, root vegetables, such as the radish, beet, and turnip, are poor in minerals and proteins, but the vitamin values of a few are excellent. They are appetizing and their abundance of indigestible fiber exerts a desirable laxative effect. The ordinary diet needs more of them.

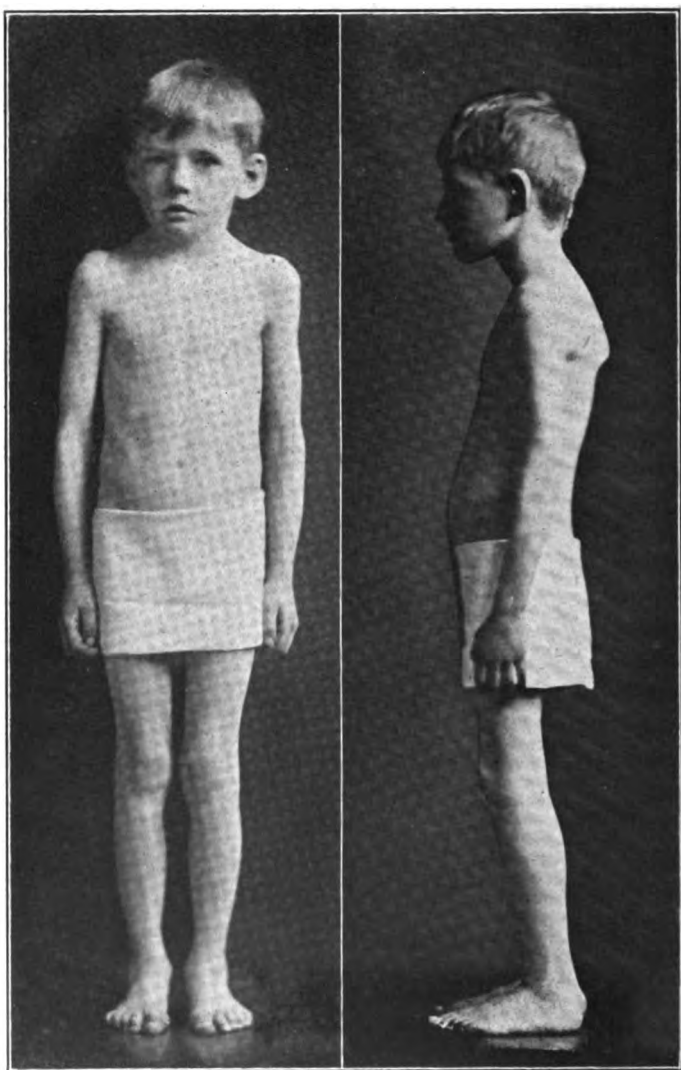
**EGGS.** Eggs can be used attractively in a great variety of ways, but they should be properly combined with other foods. They resemble milk with respect to vitamin A, and are almost six times richer in iron, but are distinctly inferior to milk in their content of calcium. The yolk should be included early in an



**A FULL FACE DOES NOT ALWAYS INDICATE A WELL NOURISHED BODY**

Herbert, aged six and one-half years, is more than two years retarded in growth. His round shoulders, protruding shoulder blades, prominent abdomen, flabby muscles, and fatigue posture are all signs of malnutrition, but his round face and regular features make him look well nourished when dressed. Defects: underweight 16 per cent (8 lb.); naso-pharyngeal obstruction; decayed teeth (two); spinal curvature; inflammation of middle ear; fatigue posture.

(From Emerson's "Nutrition and Growth in Children". Courtesy of D. Appleton and Company.)



### A TYPICAL MALNOURISHED CHILD

Alfred H., aged nine years. Notice his serious expression, mouth breathing, lines under the eyes, thin arms and legs, and pronated feet. His defects were: underweight 17 per cent (9 lb.); naso-pharyngeal obstruction; decayed teeth (eight); fatigue posture; habit spasm; congenital duodenal obstruction (bands) with gastric dilatation.

(From Emerson's "Nutrition and Growth in Children".  
Courtesy of D. Appleton and Company.)

infant's diet (one egg yolk daily by the time the child is one year old) to supplement the very low iron content of milk. Eggs are rich in proteins and their proteins effectively supplement the proteins of grains, but because of their shortage in vitamins B and C, and in calcium, together with their somewhat less valuable proteins, eggs do not make good the deficiencies of bread, grains, and potatoes quite so well as milk does. Egg fat has about the same dietary value as butter and is more valuable than such fats as lard, tallow, and the fats of vegetables and nuts.

**LEAN MEATS.** Lean meat, an essentially protein food, is rich in phosphorus and iron, but poor in the vitamins. Its calcium content is notably low, but the proteins of lean meat are good, and round out the proteins of both cereal and legume seeds in a very satisfactory manner. When taken in moderation, lean meat is a valuable food and is easily digested, but in many homes it constitutes too large a percentage of the diet and too much lean meat damages the body by burdening the excretory powers of the liver and the kidneys and loading the blood with poisonous substances which lower both mental and physical activity. On the other hand, in a number of households the meat consumption may not be excessive, but there is too little variety. This is true, no doubt, in many country homes where the supply of meat is restricted almost entirely to pork, and often to fat pork. It is wise, therefore, to see that meat is used only in moderation and that its dietary shortcomings, together with those of the cereals and tubers, are made good by the liberal use of the leafy vegetables and milk.

**CHEESE.** In the main, cheese is an appetizing form of preserved milk. It is a rich food and may produce indigestion in cases of over indulgence. Cheese from whole milk contains most of the fat and protein, a large portion of the salts present in milk, but practically none of the milk sugar. It is richer in vitamin A, but contains less of vitamin B than does milk. As a meat substitute, it is richer in calcium and in vitamin A than meat.

**SUGAR AND FATS.** Sugar is used by the body only as a source of energy. The average consumption today is about ten times what it was 100 years ago when it amounted to nearly 11 pounds per person per year. The present excessive use is due to our abnormal fondness for sweets, which costs us well, in many cases at least, in terms of lowered nutrition. Too large amounts of sugar also irritate the digestive tract and ferment readily with the production of gas when the digestion is faulty. Excessive use of sugar is to be avoided.

Fats also serve only as fuel for the body, with the exception of butter, egg, fish, and beef fats, which carry vitamin A and therefore hold a special position among fats in general. Fats are



avored also because they add richness in cooking, and because they enable the stomach to retain the food for a longer time and thereby lengthen the periods between hunger spells and the lowered working ability which hunger usually causes. As a rule, the average American home is sufficiently provided with fats, but in too many homes not enough of butter is used.

**NUTS.** Nuts are sometimes used as a substitute for meat. Most nuts are rich in fat, poor in starch, and are very well supplied with good proteins, but these are not so valuable as are the proteins of meat, eggs, and milk. Their mineral and their vitamin values resemble those of meats and the whole grains. They are, therefore, a very good substitute for other seed products, or for meat, but not for milk, cheese, butter, or eggs. The average home diet should contain more nuts.

**FRUITS.** Fruits are particularly appetizing and more abundant use of them would be both wise economy and good hygiene. Such fruits as berries, tomatoes, apples, peaches, and oranges are very good sources of vitamin B, even after cooking. When raw, they are also good sources of vitamin C, and are needed to protect against scurvy. It should be stated, however, that properly cooked tomatoes are still rich in vitamin C. The vitamin A content of fruits has received but little study. Most fruits furnish certain organic salts which have a special value in stimulating the kidneys. A number of them, such as the apple and the orange, are also very valuable because of their laxative effects.

**WATER.** Water is more vital than food. From 70 to 75 per cent of our bodies is water. Every living cell in the body must be well supplied with it in order to function rightly. In starvation an animal may lose around 40 per cent of its body weight and still live, whereas a loss of from 20 to 22 per cent of the water content of its body will cause death. Entire abstinence from water frequently results in death for man after 36 to 72 hours, although longer periods of existence have been recorded. Adults normally require 3 to 5 quarts of water per day, varying amounts of which are taken in beverages and foods, as well as in drinking water. Children need liberal supplies of water, not less than four glasses a day, because they are growing and producing new tissues. The especially important business of controlling our body temperature is dependent upon water, as is also the lubrication of our joints, eyeballs and other parts of the body where irritation would result from friction.

Contrary to the more or less prevalent opinion, careful studies have shown that the drinking of large quantities of water by normal individuals, with their meals, is beneficial. Secretion of the digestive juices is stimulated and there result a more complete utilization of the food and decreased development of harmful organisms in the digestive tract. The common

practice of drinking with every mouthful of food is harmful and should not be done. Drink freely at certain intervals during the meal, also before and after, but never for the purpose of carrying the food down. Liberal drinking before breakfast is healthful and helps to avoid constipation. For this purpose, warm water is more effective and is preferable to cool water.

**COFFEE AND TEA.** Coffee and tea contain caffeine, a habit-forming drug, which stimulates the brain and the kidneys and also affects the heart beat. Growing children should never be allowed tea or coffee because of their harmful effect upon the nervous system, and their tendency to produce a deficiency of red blood corpuscles. In a large group of children who came under the observation of Dr. Emerson of Boston, in a nutrition clinic, after having previously been under the care of visiting nurses and social workers for a considerable period of time, he found that 72 per cent were still using tea, or coffee, or both. A large number of "no-appetite" cases are the result of caffeine in coffee and tea. A half of a cup of tea contains an ordinary medical dose of caffeine. Records from clinics of Dr. Emerson in Boston, New York, and Chicago, show that about 85 per cent of the malnourished children treated used tea or coffee, or both, one or more times a day. When they are not used in excess, the enjoyment of these beverages, by adults, may offset their more or less harmful effects, but nervous persons would probably be better off without them. The aromatic oils in coffee often produce indigestion.

**YEAST.** A yeast-eating fad has developed recently, as a result of the extravagant claims of yeast manufacturers. Yeast is rich in vitamin B. It does not contain A and C. Its proteins are very good and a few people claim beneficial results from eating yeast cakes. Where such claims are actually true, they furnish evidence of a vitamin deficiency and force one to conclude that the diet in general should be corrected. It would be wiser by far to make the diet satisfactory than to depend upon something which is taken as medicine. Yeast is used in certain cases by the medical profession, and should be taken as such only upon the advice of a competent physician. In 99 cases out of 100, the chances are that if the diet is needing vitamin B; it is also in need of other essentials which yeast does not supply. The only intelligent thing to do is to round out the diet in all respects by suitable combinations of food as indicated in what has preceded, and in the menus to follow. We can not desist from closing this paragraph with the famous little poem by Doctor H. W. Wiley:—

"Soup and greens have vitamins,  
Enough for little Sid.  
So he at least will need no yeast,  
A real self-rising kid."

**COMMERCIAL VITAMIN FOODS AND MEDICINES.** Rarely indeed is there any reason for purchasing vitamins in any form except in the natural foods. Get them from the dairy, the garden, the poultry yard, and the orchard, where Nature makes them. The country has been swamped with various preparations supposed to be loaded down with these life-giving substances, which are advertised with extravagant claims that they will cure most ills, whether they be external, internal, or imaginary, and the virtues of which will also keep one young and beautiful! Even cancer is included. Doctors Hess, Moore, and Calvin of the University of Illinois Medical College have lately made careful investigation of a number of the vitamin products commonly advertised in the daily press and they were unable to discover any virtues in them. Still more recently, Dr. McCollum and his co-workers at the Johns Hopkins University have reported no value whatsoever in a long list of these preparations, even when used in dosages 20 times as large as recommended by the manufacturers!

## **OTHER IMPORTANT CONSIDERATIONS IN NUTRITION AND HEALTH**

**SOME MATTERS WHICH STARTLE US.** The report of the Army Surgeon General, showing barely 50 per cent of our young men physically fit for first line service, thoroughly shocked this nation and revealed the pronounced inferiority of our physical standards. It startled us to learn that this condition resulted primarily from habits and defects easily cured in childhood. It has been estimated that human life could be lengthened by one third if universal application were made of our present knowledge of hygiene; also that the majority of the diseases common to childhood could be avoided, and that no less than one half of the 3,000,000 or more sick beds in constant use in the United States could be stored away in attics, and even more than 600,000 deaths could be prevented every year if only practical preventive measures were taken promptly. We are told further that the annual loss to our country, due to such negligence, reaches the stupendous sum of \$1,500,000,000, which figure fails to include the costly inefficiencies of countless other persons who go about half-well. It is now agreed that the prevention of tuberculosis, which until recently caused one out of every ten deaths in this land, is principally a dietary problem. Our standards of wellness and illness and of the highest physical development are entirely too low. The integrity and permanency of our nation rest upon the fitness and health of our people. To avoid certain deficiency diseases is not enough; the danger line of nutritional disorders must also be avoided. It is said that this nation spends around \$500,000,000 for drugs every year, and that no less than \$300,000,000 of this amount is worse than wasted on the so-called "patent"

medicines. We are also misspending enormous sums of money in our endeavors to provide the best education for children handicapped by ill health, when the expenditure of a dollar now on a sensible health program might save a thousand or more dollars a few years later, and prove to be much more fruitful for the child, for human society, and for the nation. The most effective attack on the disabling diseases of middle life can be made only by adopting preventive and curative measures in childhood and youth. The bill of health, to be paid in later life, is incurred in these earlier years. One who is well at 18 has the best insurance on health for the rest of his life.

**MALNUTRITION, ITS CAUSES AND REMEDIES.** It is a matter for grave concern that recent investigations have shown that approximately one third of all our school children are malnourished. This condition is just as common among the children in the homes of the well-to-do as it is among the children to be found in any other class of homes. Malnutrition is no respecter of persons. Our gross neglect has so accustomed us to seeing it in children that our sense of guilt has been deadened. But this makes the condition no less tragic. Seventy-five per cent of our school children suffer from one or more physical defects, the vast majority of which can easily be corrected. Our children of pre-school age are no better off. These same children are to become the citizens of our next generation and the makers of our future civilization.

While there are, of course, various degrees of malnutrition, we can picture on the one side the healthy, well-nourished child who is active physically and mentally, who is able to work hard and play hard and who is blessed with good appetite, good digestion, good color, good disposition, cheerful expression, bright eyes, glossy hair, sound teeth, elastic step and firmly-developed muscles, and on the other side the malnourished child, usually thin, but sometimes fat and soft, lacking mental and physical vigor, whose hair is rough, tongue coated, teeth decayed, breath foul, skin loose, muscles undeveloped, and chest flat and narrow. Such a child is usually nervous, irritable, forgetful, and inattentive, and he frequently has adenoids, diseased tonsils, and other defects. There seems to be little room for doubt but that the chief cause of malnutrition is the unwise selection of food, although Dr. W. R. P. Emerson of Boston gives first consideration to physical defects, especially infections and obstructions in the nose and throat. He lists as other important causes, in addition to improper diet and faulty food habits, the lack of home control, over-fatigue, and faulty health habits, and states that "the requisites for good health in the growing child are few,—good air, simple food, rest, and proper exercise". He finds that malnourished children average about six physical defects to one or less for those properly nourished. Doubtless there are many

thousands of cases of malnourishment where medical attention must go hand in hand with proper diet, but there are many reasons for believing that the question of correct diet has received far too little attention by the medical profession. Many defects among school children which now require surgical and medical attention are the outcome of the unwise selection of foods for generations past. The average parent does not know that there is a most vital connection between food habits and physical condition; neither does he know what a really healthy child is like; unless his child attracts special attention because of complaints, he considers that all is well.

Medical examinations of a large number of the 20,000,000 or more school children in the U. S. have revealed, aside from the large number suffering from malnutrition, that from 12,000,000 to 18,000,000 have defective teeth, from 3,000,000 to 5,000,000 have diseased tonsils, adenoids, or other glandular defects, from 2,000,000 to 4,000,000 have deformed feet, weak spines or other joint defects, that 5,000,000 have defective eyes, most of which can be corrected, that about 1,000,000 are tubercular, that at least 250,000 have heart disease and about the same number are mentally defective. Obviously, our great national problem of malnutrition must be solved by the united efforts of the medical clinic and the nutrition expert. With the proper study and attention the vast majority of malnourished children can be made well in their own homes.

**THE EFFECT OF DIET ON THE TEETH.** Previous to about 1850 the Icelanders, who lived on mutton, milk, eggs, fish, and a few vegetables, enjoyed practically perfect teeth, but after the importation of cereals and sugar and their abundant consumption by the islanders, decayed teeth became common because of the pronounced mineral shortcomings in the modified dietary. We learn, also, that the Eskimo language formerly contained no word for "toothache", but today the teeth of the Eskimo children are no better than are those of American children. From 60 to 80 percent of our school children have defective teeth, all of which are more or less injurious to their health, and some of which are even deadly menaces to their owners. The soundness of a child's first teeth is very largely determined before birth, and the enamel of all but the second and third molars of the permanent set is made before the sixth year of age. Very few children fed in infancy on sweetened condensed milk seem able to escape poor teeth. In a study of 1,100 children in Seattle, Washington, over 72 per cent of those fed in infancy on sweetened condensed milk showed decayed teeth as compared to 43 per cent among those who were nursed for several months and then placed on cow's milk. A survey was recently made of 6,000 children of Gary, Indiana, who ranged in ages from two to six years. Medical examination showed that the decay of the teeth

varied from ten per cent in the group of children whose simple and inexpensive diet included, among other things, a good supply of milk, vegetables and fruits, to eighty per cent in another group whose diet was deficient in these essential foods. The daily diet will be plentifully supplied with minerals if liberal use is made of milk, the leafy vegetables, eggs, and fruits. Doctor J. H. Carter examined the mouths of a great number of people of the Slavic race and found that their teeth were practically free from decay. These people are isolated from villages and take their foods just about as they are produced in the natural state, which means that they are eaten in a much less refined condition than are most of our own foods. They use extremely large quantities of fresh milk, fresh vegetables and fresh fruits, and large quantities of black bread and of cereals, particularly oatmeal. These foods furnish them an abundance of the vitamins and of the essential minerals. They eat very little animal protein and this consists chiefly of chicken and pork. Their average sugar consumption per person per year is around eight pounds, approximately thirteen times less than the average consumption reported for the United States during 1922. Coffee is not used at all. Tea is used irregularly and without sugar.

Dr. F. M. Wells of England has studied the effect of the diet upon the teeth of the Scotch people, and reports very little tooth decay among the older generation of the Highland Scotch, who until a few years ago lived on a very simple and natural diet, about as follows:

**Breakfast**—Oatmeal, milk, syrup or treacle, and some butter.

**Dinner**—Potatoes, salt herring, milk, oat cake.

**Supper**—Oatmeal (brose) made with milk. Between dinner and supper a glass of milk.

**Sunday dinner**—Boiled cabbage and turnips.

**Sunday supper**—Boiled potatoes, fresh fish, (pork occasionally).

Dr. Wells also found that these older Highland Scotch had better bones than were to be found in any other part of the British Isles, but today their children show considerable decay of the teeth due to their more modernized diet in which such foods as oatmeal and potatoes have been replaced by white bread, syrup, jam, and tea. Among the Lowland Scotch the housing and sanitary conditions are much better, but nearly every person has decayed or false teeth because the diet is poorly supplied with the necessary minerals, such as calcium and phosphorus.

**OVERWEIGHT.** Comparatively little attention has been given to overweight in children, perhaps chiefly because it has been considered as a discomfort more or less hereditary, and not necessarily dangerous. It is, nevertheless, a menace to health when it exceeds the height-weight tables now in use, by more

than 20 per cent. Although the fat child is usually good natured and sweet-tempered, the excess fat becomes an extra burden upon the vital organs and lessens the child's endurance, activity, and resistance to disease. The examination of many children shows on the average six physical defects for the underweight and less than two for the overweight children. It has been stated that "The overweight is at least twice and at some ages forty times as liable to diabetes". In a general way, the younger the child the less is the danger from overweight. The chief cause of fatness is the eating of high-energy foods such as the fats and sugars. The remedy is to reduce, as far as possible (not suddenly, however), such foods as fat meats, pastries, artificial sweets, candies, and cream, and substitute in their places the leafy and the root vegetables which provide the necessary bulk to satisfy the appetite and prevent constipation, fruits such as apples and oranges, lean meats in moderation, salads with little oil, and whole cereal breads. The fat person may reduce in a more heroic manner by fasting for one or two days, at intervals, in addition to carrying out the necessary changes in diet. Diet is the essential remedy, but proper physical exercise is a valuable aid and should be encouraged. **The use of drugs is worthless and generally harmful.** It should be remembered, too, that obesity is usually the result of incorrect food habits rather than the outcome of a natural family characteristic. Occasionally it may result from the impairment of the thyroid gland.

**A WORD TO THE MOTHER.** Truly, the duties of the mother are many and varied, but one of the greatest services which she can render to the nation, in its present great war against human frailties and diseases, is the intelligent feeding of the members of her own family. Indeed, the one best time to give her children the greatest benefits of proper nutrition is **during their prenatal life and early infancy.** Beginning with the fifth month of the prenatal life of her child the mother's diet very largely determines whether her child shall have sound and perfect teeth or unsound and faulty teeth. The period of teeth formation is a significantly important one in the child's life. The enamel is already formed before the teeth make their appearance through the gums and there is no remedy if a poor job has been made of it. Every mother knows that a child's teeth are of prime importance in the health of that child, and if she is nursing that child, she need not be told that it is her own diet which determines the quality of its teeth.

It appears that the health of the child from two to six years of age receives but little care, and yet mortality records show that these are critical years. The establishment of good health during these critical years is exceedingly important, but the attention given to physical defects and proper habits of diet and

sleep amounts, in countless instances, to little less than criminal negligence. We learn that 90 per cent of the cases of measles and whooping cough and more than 95 per cent of the deaths caused by these diseases occur under the age of five, and that practically the same rating is true for scarlet fever and diphtheria; also, that more than 50,000 children in this country succumb to these four diseases each year; and of this number 35,000 die before their fifth year, and many who survive continue to suffer from complications and after-effects. In fact, it is said that one fourth of all deaths occur before the sixth year is reached, or six times as many as occur during the next ten years of life.

**The malnourished child is truly sick, but his illness cannot be cured by nostrums, nor even by drugs legitimately prescribed for various other bodily weaknesses. A knowledge of the essentials of growth and health is the greatest safeguard against malnutrition and the outstanding purpose of this bulletin is to help in securing that knowledge. A child's assimilation of his food can be very much disturbed by such emotions as fear, anger, and worry. Happiness promotes health. Wrong methods of physical punishment when punishment becomes the last resort, such, for example, as postponement of the punishment until the next day, or sending the child off to bed without supper, not only defeat their own purpose, but they also injure the child. Forced feeding is also very bad practice when the child is not hungry. Regulate his activities so that he will be hungry. Often he may be "too tired to eat". Avoid the use of foods as carriers for medicines. Among the rich, catering to childish whims results in many cases of malnutrition. Simple and natural foods properly chosen and well prepared are not only safe and sane, but sufficient. Do not forget that attractiveness appeals to the child as much as to any one.**

**A WORD TO THE TEACHER AND THE NUTRITION WORKER.** There is no better way to bring the school and the home into a closer relationship than through the health problems of the boys and girls in our schools. There is no problem of greater interest to any child than that of securing and maintaining for himself the very best in health so that he may carry his studies and sports. The sooner the very best information relating to the proper habits of diet and to the preservation of health can be carried to the home from the school, the sooner shall we have started on the right road to better homes, a more efficient education, and a greater nation. A child should be as well grounded in the things which make for health and a sound body as he is in the principles of language, arithmetic, or history. One can not ask for a more favorable opportunity to teach correct food habits and food values. Nor can one find a challenge to a higher public service. It is true that from 35 to 50 per cent of the pupils in our



high schools, because of their physical condition, are forever worrying about examinations and promotions. In many cases this condition leads to failure in classes and even many of those who graduate are physically unfit to begin their real life work.

Investigations point out that about 40 in every 100 malnourished children feel the necessity of late night study because of their lowered working efficiency and also because they do not want to be branded as "quitters". It is not reasonable to expect from three to four hours of continuous school work from such children, as is often the case, when most adults tire from an hour or two of hard study. Such expectations are neither fruitful nor possible of realization. The only right thing to do with that malnourished child who is forever tired, who merely leans around and looks on while his companions play, who is but a drag to himself as well as to the school, and who may even grow to manhood and become the father of children handicapped by low vitality, is to take corrective measures while he is yet a child. **To fail the undernourished child is but to fail the nation!**

**PLANNING THE DIET.** The more economically one must live, the greater the probability that he will depend upon bread or other grain products to meet his food requirements, because these supply his energy needs at the lowest cost. Unquestionably the most common diet to be found in our homes is that represented by bread, syrup, meat, and potatoes. This type of a diet is incomplete. It lacks **quality**. The effects of this lack of quality are seen in lowered mental and physical ability, lack of interest in one's work, underweight, imperfect bone growth, decayed teeth, and the deterioration of other parts of the body. But the bread, potato, molasses and meat diet can be made complete, and the necessary **quality** added to it by simply making the proper combinations with other foods. The fact that a diet is not poor enough to bring on some deficiency disease does not in any sense mean that it is satisfactory. We must avoid the treacherous effects of poor diets, which crop out in many ways, and we must plan our diets with a view to promoting the very best physical and mental development, in addition to increasing our years of usefulness and happiness. "A quart of milk a day for every child" is a fine rule, and a pint a day for every grown-up is also desirable. Probably the best all-round plan to guarantee a satisfactory and well-balanced diet as regards the essential mineral elements, the vitamins, and the proteins, is to adopt a standard such as follows:

An adult should eat each day:

1. **ONE PINT OF MILK.** Milk furnishes an excellent combination of the essential mineral elements with the exception of iron, excellent proteins for muscle building, and the necessary vitamins.

2. **TWO SERVINGS OF VEGETABLES BESIDES POTATOES.**

**TOES.** Potatoes furnish energy. Root vegetables, such as the turnip, beet, parsnip, carrot, and rutabaga furnish bulk to aid the intestine and also provide certain minerals and certain of the vitamins. The leafy vegetables, such as spinach, chard, cress, lettuce, dandelion, and cabbage, provide iron and other minerals abundantly and also the vitamins, as do also fresh string beans. Mature beans and peas furnish vitamin B and proteins of a medium quality.

**3. TWO SERVINGS OF FRUIT.** Canned or preserved fruits, such as berries, plums, peaches, and grapes, are valuable for organic acids and potassium.

**4. ONE SERVING OF MEAT(OR FISH OR EGG).** Muscle meats are rich in phosphorus and iron and contain excellent proteins for tissue building. Eggs contain excellent proteins, and are rich in vitamins A and B and also in minerals with the exception of calcium.

**5. AT LEAST ONE WHOLE CEREAL IF OBTAINABLE.** Whole cereals such as rolled oats and whole wheat flour or grain containing the germ are rich in vitamin B. Highly milled grains furnish little except energy, because nearly all of their vitamin, mineral, and protein values are removed in the milling processes.

**6. SOMETHING RAW,—FRUIT OR VEGETABLE AT LEAST ONCE A DAY.** Vitamin C is easily destroyed by heat. Raw vegetables, such as cabbage, lettuce, and onions, and raw fruits, such as tomatoes, oranges, and apples, will insure a sufficient quantity of vitamin C to promote health and to protect against scurvy.

**7. BREAD AND BUTTER.** White bread made with milk furnishes little except food for energy. On the other hand, whole wheat bread made with milk provides, in addition to its energy value, good quantities of vitamins A and B, a more satisfactory mineral content, and a larger quantity and better quality of protein. Butter supplies energy for the body and is also an excellent source of vitamin A.

The meals from day to day in many of our homes not only fail to promote health and vigor in the adult, but they also do that which is worse in their failure to promote growth and normal development in our children, who **must have milk, vegetables, especially the leafy vegetables, fruit, and whole grains.** A faulty diet causes early aging and shortens life. Illness cannot be prevented on improperly chosen foods and preventable illness is expensive and wasteful.

The menus which follow have been prepared to show a varied selection and satisfactory combination of our different foods during the different seasons of the year. Left-overs have not been considered, as a large variety of choice was desired to

give suggestions. The housewife will, of course, not change her meals as completely daily but will, in a longer time, work in the numerous suggestions.

For the man working hard out of doors every day heavier suppers would have to be supplied. Eggs, cold meat, or cheese and potatoes could be easily added for him. The housewife and older children would be in better health without the heavy supper but the man would need it.

#### DIET FOR CHILD TWO YEARS OLD

|                                                                                                                                                                                                                                                                    |                                                                                                                                                                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MONDAY.                                                                                                                                                                                                                                                            | 12:30 P. M.<br>Soft Poached Egg<br>Dry Toast<br>Spinach<br>Milk to Drink<br>3:00 P. M.<br>Milk to Drink<br>Cracker<br>5:30 P. M.<br>Milk Toast                                |
| 7:00 A. M.<br>Well-cooked Oatmeal<br>Cream and Sugar<br>Warm Milk to Drink<br>Dry Toast<br>10:00 A. M.<br>Juice of one Orange<br>Graham Cracker                                                                                                                    |                                                                                                                                                                               |
| TUESDAY.                                                                                                                                                                                                                                                           | 3:00 P. M.<br>Baked Apple<br>Milk to Drink<br>5:30 P. M.<br>Coddled Egg<br>Dry Toast<br>Warm Milk to Drink                                                                    |
| 7:00 A. M.<br>Prune Pulp<br>Warm Milk to Drink<br>Graham Bread Toast<br>1 Slice Bacon<br>10:00 A. M.<br>Well-cooked Corn Meal<br>Cream and Sugar<br>12:30 P. M.<br>Chicken Broth with Barley<br>Croutons<br>Spinach or Mustard Greens<br>Strained<br>Milk to Drink |                                                                                                                                                                               |
| WEDNESDAY.                                                                                                                                                                                                                                                         | 12:30 P. M.<br>1 slice Bacon<br>Baked Potato<br>Bread and Butter<br>Apricot Pulp<br>3:00 P. M.<br>Hot Chocolate and Cracker<br>7:30 P. M.<br>Cream of Tomato Soup<br>Croutons |
| 7:00 A. M.<br>Juice of one Orange<br>Well-cooked Farina<br>Cream and Sugar<br>Warm Milk to Drink<br>10:00 A. M.<br>Milk to Drink<br>Graham Crackers                                                                                                                |                                                                                                                                                                               |

## THURSDAY.

7:00 A. M.

Warm Milk to Drink  
Well-Cooked Ralstons  
Cream and Sugar  
Stewed Pears

10:00 A. M.

Beef Broth  
Toast

12:30 P. M.

Scrambled Egg in Milk  
Toast  
Baked Banana  
Milk to Drink

3:00 P. M.

Graham Bread  
Apple Sauce

5:30 P. M.

Strained Vegetable Soup  
Toast

## FRIDAY.

7:00 A. M.

Cooked Wheatina  
Cream  
Toast  
Warm Milk to Drink

10:00 A. M.

Milk and raw Egg beaten together  
Soda Crackers

12:30 P. M.

Cream of Pea Soup  
Soft Shirred Egg  
Graham Bread and Butter  
Tapioca Cream

3:00 P. M.

Juice of one Orange  
Graham Crackers

5:30 P. M.

Cooked Rice  
Cream and Sugar

## SATURADY

7:00 A. M.

Warm Milk to Drink  
Cream of Wheat  
Sugar and Cream  
Toast (Dry)  
Bacon

10:00 A. M.

Juice of Orange

12:30 P. M.

Cream of Potato Soup  
Tender Asparagus, Strained  
Graham Bread and Butter  
Prune Whip

3:00 P. M.

Graham Bread  
Peach Marmalade

5:30 P. M.

Soft Cup Custard  
Toast  
Warm Milk to Drink

**SUNDAY.**

7:00 A. M.

Warm Milk to Drink

Soft Boiled Egg

Toast

10:00 A. M.

Pineapple Juice

Graham Crackers

12:30 P. M.

Well-cooked Chicken Breast

Mashed Potato

Bread and Gravy

Celery

Ice Cream and Hard Wafers

3:00 P. M.

Zweibach

Milk

5:30 P. M.

Creamed Carrots

Toast

Warm Milk to Drink

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Note: We do not wish to create a desire for High Flavored Foods; so encourage only a small amount of sugar, butter, very little salt and no pepper. All the cereal should be thoroughly cooked, which means several hours, on a slow fire, or until it is cooked enough so it can be strained. Variety and attractiveness are as important with children as with adults, and the vegetables, fruits, and cereals should all be varied according to season.

---

**MENUS FOR FALL FOR ADULTS**

Recipes are given in this bulletin for the dishes which are starred.

**MONDAY****BREAKFAST.**

Orange

Puffed Wheat, Sugar,  
Cream

Poached Egg on Toast

Toast, Butter

Coffee, Sugar, Cream

**DINNER.**

Broiled Steak

Potatoes Au Gratin

Creamed Peas and  
Carrots

Bread and Butter

Waldorf Salad, Saltines

**SUPPER.**

Cream of Tomato Soup

Head Lettuce Salad

French Dressing

Bread and Butter Sand-  
wiches

Hot Chocolate

**TUESDAY****BREAKFAST**

Grapes

Oatmeal, Sugar, Cream

Sliced Bacon

Corn Cakes, Butter and  
Molasses

Coffee, Sugar, Cream

**DINNER**

Roast Pork and Gravy

Candied Sweet Potatoes

\*Slaw

Corn Bread

Apple Tapioca &amp; Cream

**SUPPER**

Welsh Rarebit on

Toast

Potato Chips

Nut Bread Sandwiches

## WEDNESDAY

## BREAKFAST

Bananas and Cream of  
Wheat  
Sugar and Cream  
Scrambled Eggs  
Toast and Butter  
Coffee, Sugar, Cream

## DINNER

Veal Cutlets  
Potatoes on Half Shell  
Creamed Celery  
Beet Salad  
Hot Rolls and Butter  
\*Jelly Roll with Cream

## SUPPER

Stuffed Peppers  
Sliced Tomatoes  
Bread and Butter  
\*Cream Puffs

## THURSDAY

## BREAKFAST

Fresh or Stewed Pears  
Hot Toasties  
French Toast & Syrup  
Toast and Butter  
Coffee, Sugar, Cream

## DINNER

Broiled Sweet Breads  
Potatoes a la Golden  
Rod  
Parsnips or Turnips  
Bread and Butter  
Fresh Apple Pie

## SUPPER

\*Baked Stuffed Egg  
Plant  
Fruit Salad  
Bread and Butter Sand-  
wiches  
Hot Chocolate

## FRIDAY

## BREAKFAST

Orange  
\*Shirred Eggs  
Hot Biscuit and Butter  
Honey  
Coffee, Cream, Sugar

## DINNER

Baked Fish  
French Fried Potatoes  
Creamed Onions  
Corn Muffins & Butter  
Stuffed Tomato Salad  
and Cheese Straws

## SUPPER

Club Sandwiches  
Hot Chocolate  
Baked Apple

## SATURDAY

## BREAKFAST

Grape Nuts, Sugar,  
Cream  
Bacon & Fried Apples  
Graham Muffins  
Butter  
Coffee, Cream Sugar

## DINNER

Fried Ham and Gravy  
Baked Sweet Potatoes  
Escalloped Corn  
Bread and Butter  
Cucumber Pickles

## SUPPER

Baked Beans  
Brown Bread  
Sweet Milk  
Fruit Gelatin

## SUNDAY

## BREAKFAST

Orange  
Puffed Rice, Cream,  
Sugar  
Broiled Mackerel  
Hot Biscuit, Butter  
Coffee, Cream, Sugar

## DINNER

Roast Duck and Dress-  
ing  
Mashed Potatoes  
Creamed Cauliflower  
Hot Rolls and Butter  
\*Huntington Salad  
with Stuffed Dates  
Orange Sherbet with  
Cookies

## SUPPER

Salmon and Peas  
Celery  
Buttered Toast  
Chocolate Cake

**MENUS FOR WINTER FOR ADULTS****MONDAY****BREAKFAST**

Stewed Prunes  
Fried Mush and Syrup  
Buttered Toast  
Coffee, Sugar, Cream

**DINNER**

Liver and Onions  
Creamed Turnips  
String Beans  
Bread and Butter  
Canned Berries

**SUPPER**

Toasted Bacon and Tomato Sandwiches  
Mayonnaise  
Hot Chocolate  
Baked Custard

**TUESDAY****BREAKFAST**

Stewed Dried Figs or Canned Figs  
Oatmeal, Sugar, Cream  
Pork Sausage  
Corn Cakes, Sorghum  
Coffee, Sugar, Cream

**DINNER**

Fried Rabbit  
Escalloped Cabbage  
Buttered Peas  
Bread and Butter  
\*Brown Betty and Hard Sauce

**SUPPER**

Vegetable Soup  
Crackers and Olives  
Baked Apples  
Ginger Bread  
Hot Chocolate

**WEDNESDAY****BREAKFAST**

Cream of Wheat with Dates  
Bacon  
Hot Biscuits, Butter  
Strawberry Jam  
Coffee, Cream, Sugar

**DINNER**

Fresh Baked Ham  
Candied Sweet Potatoes  
Spinach with Hard Boiled Egg  
Apple Sauce  
Hot Rolls and Butter

**SUPPER**

Apple and Peanut Salad  
Saltines  
Oven Fried Potatoes  
Doughnuts

**THURSDAY****BREAKFAST**

Orange  
Cereal, Cream, Sugar  
Puffy Omelet  
Buttered Toast  
Coffee, Cream, Sugar

**DINNER**

Roast Ribs of Beef  
Hash Brown Potatoes  
Buttered Lima Beans  
Bread and Butter  
\*Pineapple Jelly

**SUPPER**

\*Turkish Pilaf or Rice and Tomatoes  
Buttered Toast  
Apple Sauce  
Hot Chocolate

**FRIDAY****BREAKFAST**

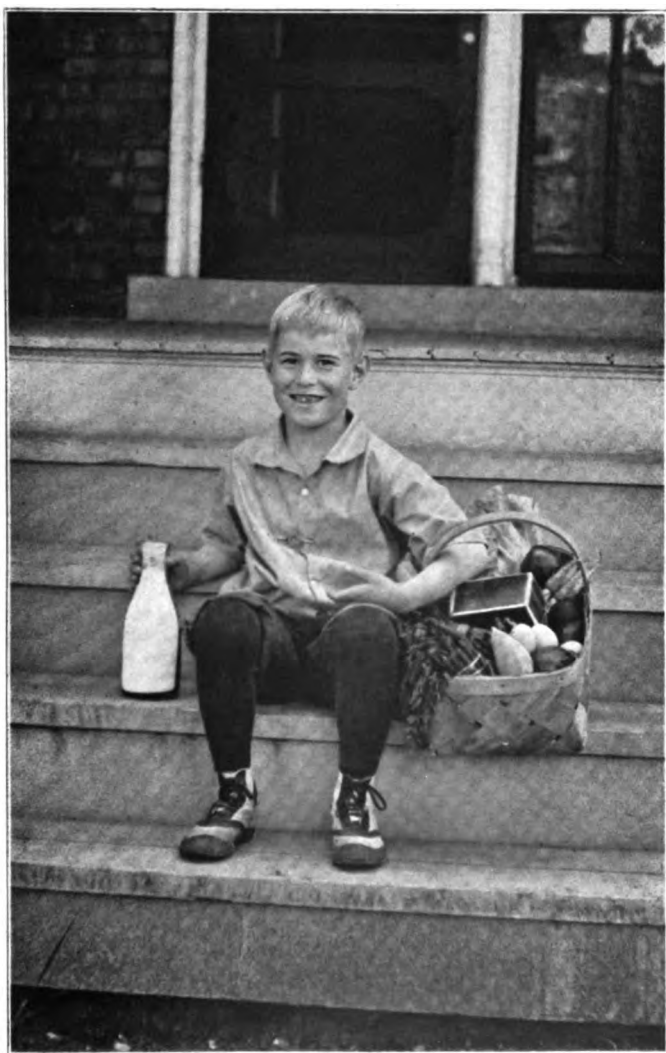
Baked Apple  
Cereal, Cream, Sugar  
Bacon  
Coffee Cake  
Coffee, Cream, Sugar

**DINNER**

Spare Ribs  
Potatoes on Half Shell  
Peach Pickle  
Hot Rolls and Butter  
Waldorf Salad  
\*Marshmallow Teas  
Pumpkin Pie

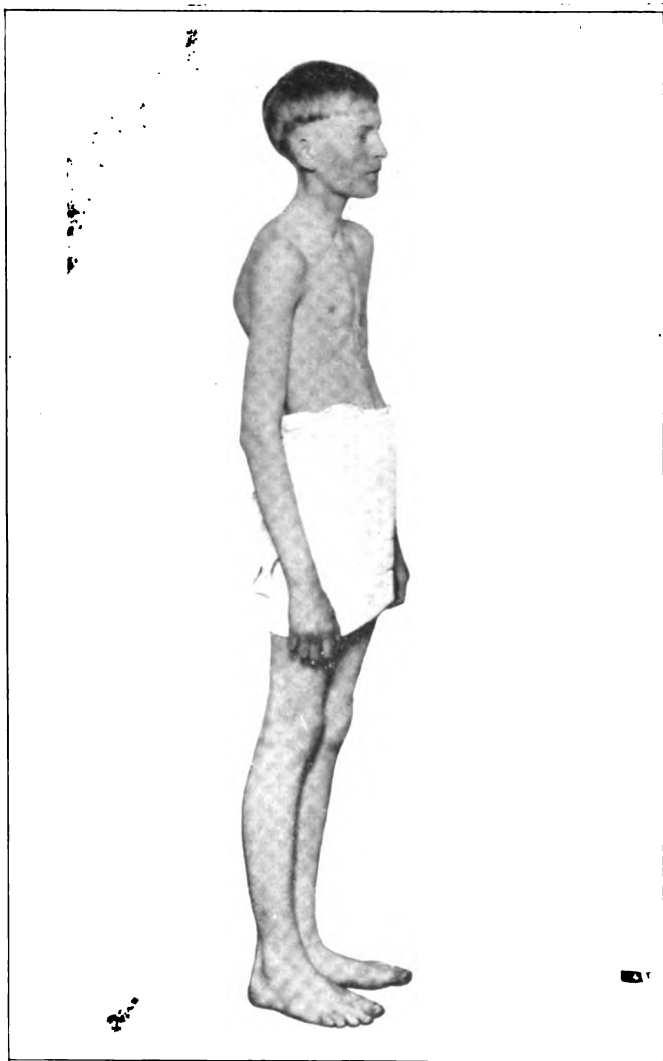
**SUPPER**

Creamed Dried Beef  
Black Eyed Peas  
\*Cole Slaw  
Corn Bread and Butter



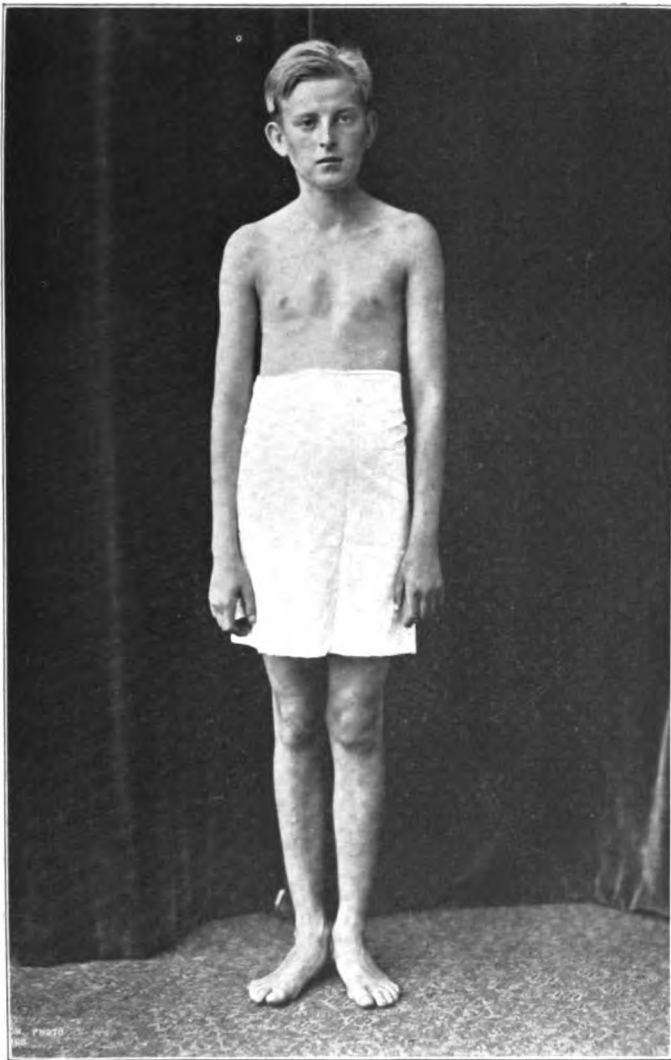
**Milk, eggs, fruits, and vegetables (especially the green leafy vegetables such as spinach, lettuce and cabbage) keep children growing, healthy, and happy. From these foods come the vitamins, the minerals, and the proteins which are required to make perfect teeth and bones, pure blood, and firm strong muscles, all of which are vital to long life and usefulness.**





Adam was refused a working certificate on account of his malnourished condition. He was one of a group of boys sent to Arden Shore camp at Lake Bluff, Illinois, (not far from Chicago), where he was given good, simple food, with one quart of milk a day. The boys had several hours of school work, proper light exercise out of doors, a morning lunch at 10:30 of milk and crackers, and a similar one at 3:30. These lunches were followed by a rest period of one hour in the morning and half an hour in the afternoon. The boys went early to bed and slept in the open air. Under this regime Adam improved remarkably, as may be seen by his photograph on the next page.

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At the end of Adam's stay at the camp, he had no difficulty in obtaining his working certificate and in holding a position. This remarkable transformation was brought about by the adoption of correct food and health habits.

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**A DIFFERENCE OF FIVE YEARS IN AGE AND OF FOUR  
POUNDS IN WEIGHT**

Paul is eight years old and weighs 33 pounds; his brother Ralph is three, and weighs 29 pounds. Paul is stunted both in height and in weight because of improper food habits. He did not like milk, bread, butter, fish, or meat; he washed his food down with liquids; and he was allowed to sit at the table and play with his food while the others were eating. His mother says he is "Irritable and cranky". Ralph, on the other hand, is strong, good natured, and happy.

(From Emerson's "Nutrition and Growth in Children"  
Courtesy of D. Appleton and Company.)

**SATURDAY****BREAKFAST**

Tokay Grapes  
Shredded Wheat,  
Cream, Sugar  
Waffles and Molasses  
Coffee, Cream, Sugar

**DINNER**

Fried Oysters, Catsup  
Steamed Rice  
Succotash  
Corn Bread and Butter  
Sliced Oranges and  
Cocoanut

**SUPPER**

Sardine Sandwiches  
Toasted  
Potato Cakes  
Graham Muffins, Butter  
Grape Jelly  
Milk

**SUNDAY****BREAKFAST**

Half Grape Fruit  
Brains and Scrambled  
Eggs  
Buttered Toast  
Jam  
Coffee, Cream, Sugar

**DINNER**

Baked Chicken and  
Giblet Gravy  
Dressing  
Mashed Potatoes  
Asparagus Tips on  
Toast  
Hot Rolls and Butter  
Pear Salad, Mayonnaise  
Ice Cream and Vanilla  
Wafers

**SUPPER**

Creamed Mushrooms  
on Toast  
Potato Chips  
Head Lettuce Salad and  
French Dressing  
Cinnamon Rolls

**MENUS FOR SPRING FOR ADULTS****MONDAY****BREAKFAST**

Stewed Rhubarb  
Post Toasties, Sugar,  
Cream  
Bacon  
Bran Muffins, Butter  
Coffee, Cream, Sugar

**DINNER**

Lamb Chops  
Spinach with Egg  
Bread and Butter  
Watercress Salad, May-  
onnaise

**SUPPER**

Macaroni and Cheese  
Toast and Butter  
Baked Tomatoes  
Hot Chocolate

**TUESDAY****BREAKFAST**

Stewed Apricots  
Grape Nuts, Cream,  
Sugar  
Ham Omelet  
Hot Biscuit and Butter  
Coffee, Cream, Sugar

**DINNER**

Roast Beef  
Potato Balls  
Dandelion and Mustard  
Greens  
Corn Bread and Butter  
Gooseberry Tarts

**SUPPER**

Boiled Ham  
\*Fried Green Tomatoes  
Graham Bread, Butter  
Jam  
Milk

## WEDNESDAY

## BREAKFAST

Apple Sauce  
Hominy Grits, Bacon  
Toast, Butter  
Coffee, Sugar, Cream

## DINNER

\*Nut Loaf  
Potatoes  
New Asparagus on  
Toast  
Bread and Butter  
\*Marshmallow Ginger-  
bread

## SUPPER

Fried Rice  
\*Spring Salad  
Radishes  
Bread and Butter Sand-  
wiches  
Milk

## THURSDAY

## BREAKFAST

Orange  
Creamed Chipped Beef  
on Toast  
Corn Muffins & Butter  
Molasses  
Coffee, Cream, Sugar

## DINNER

Veal with Tomato  
Sauce  
Potatoes  
\*Jellied Vegetable  
Salad  
Bread and Butter  
Milk, Date Bars

## SUPPER

\*Baked Bananas  
Lettuce Salad and  
French Dressing  
Hot Toast and Butter  
Hot Chocolate

## FRIDAY

## BREAKFAST

Strawberries and  
Cream  
Poached Eggs on Toast  
Toast, Butter  
Coffee, Cream, Sugar

## DINNER

Fried Frog Legs with  
Tartar Sauce  
Steamed Rice  
Green Beans Creamed  
Bread and Butter  
Cherry Pie

## SUPPER

French Fried Potatoes  
Green Onions  
Bread and Butter Sand-  
wiches  
Raisin Custard

## SATURDAY

## BREAKFAST

Fresh Cherries  
Cereal, Cream, Sugar  
Waffles and Molasses  
Coffee, Cream, Sugar

## DINNER

Swiss Steak  
Stuffed Baked Potatoes  
\*Orange Star Salad  
Bread and Butter

## SUPPER

Cream of Tomato Soup  
Toasted Cheese Sand-  
wiches  
Fruit Salad  
Toast, Butter

## SUNDAY

## BREAKFAST

Dewberries and Cream,  
Sugar  
Eggs  
Toast and Butter  
Marmalade  
Coffee, Sugar, Cream

## DINNER

Fried Chicken and Gib-  
let Gravy  
Creamed New Potatoes  
and Peas  
Buttered Asparagus  
Hot Rolls and Butter  
\*Strawberry Salad  
\*Coffee Ice Cream  
\*Caraway Seed Cookies

## SUPPER

Creamed Eggs  
Lettuce Sandwiches  
Chocolate Cake  
Milk

VITAMINS, HEALTH, AND THE DAILY DIET  
MENUS FOR SUMMER FOR ADULTS

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MONDAY

BREAKFAST

Raspberries and  
Cream, Sugar  
Bacon  
Butter, Toast, Jelly  
Coffee, Cream, Sugar

DINNER

Cold Tongue  
Creamed Potatoes  
Turnip Greens  
Corn Bread, Butter  
Milk

SUPPER

Tomato and Cottage  
Cheese Salad  
with Mayonnaise  
Pread and Butter Sand-  
wiches  
Lemonade  
Fresh Peaches, Sugar  
Cookies

TUESDAY

BREAKFAST

Strawberries  
Shredded Wheat  
Cream and Sugar  
Toast, Butter  
Orange Marmalade  
Milk

DINNER

Broiled Steak  
Baked Potatoes  
Corn on Cob  
Bread and Butter  
Lemonade  
Cinnamon Rolls

SUPPER

Potato Salad  
Deviled Eggs  
Bread and Butter  
Water-melon

WEDNESDAY

BREAKFAST

Fresh Plums  
Post Toasties, Sugar,  
Cream  
Fried Ham, Milk Gravy  
Cornmeal Muffins and  
Butter  
Coffee, Cream, Sugar

DINNER

Roast Leg of Lamb,  
Mint Sauce  
Steamed Rice  
Creamed String Beans  
Bread and Butter  
\*Cucumber Cups

SUPPER

\*Cheese Soufflé  
Cinnamon Toast  
Milk  
Black Raspberries  
Sugar, Cream  
Sponge Cake

THURSDAY

BREAKFAST

Iced Cantaloupe  
Poached Egg on Toast  
Toast, Butter, Jelly  
Coffee, Cream, Sugar

DINNER

Cold Roast Chicken  
Apple Sauce  
Succotash  
\*Cole Slaw  
Bread and Butter  
Sliced Peaches and  
Whipped Cream

SUPPER

\*Wilted Lettuce with  
Bacon  
Tomato Sandwiches  
Cream Pie

## FRIDAY

## BREAKFAST

Blackberries, Cream,  
Sugar  
Puffed Rice  
Bacon  
Hot Biscuit and Butter  
Coffee, Cream, Sugar

## DINNER

Fried Cat Fish  
Escalloped Potatoes  
Sliced Tomatoes  
Corn Bread, Butter  
Strawberry Short Cake  
and Cream

## SUPPER

Creamed Chicken on  
Toast  
Lettuce and Mayon-  
naise  
Corn on Cob  
Toast and Butter

## SATURDAY

## BREAKFAST

Strawberries, Sugar  
Grape Nuts, Cream,  
Sugar  
Eggs in Shell  
Rye or Corn Muffins  
Coffee, Cream, Sugar

## DINNER

\*Veal Birds  
Macaroni Croquettes  
Cream Sauce  
Bread and Butter  
Spiced Peaches

## SUPPER

\*Peanut Salad Sand-  
wiches  
Potato Chips  
\*Pineapple Whip and  
Wafers

## SUNDAY

## BREAKFAST

Iced Cantaloupe  
Mushrooms on Toast  
Buttered Toast  
Jelly  
Coffee, Cream, Sugar

## DINNER

Fried Chicken and  
Gravy  
Mashed Potatoes  
Swiss Chard  
Hot Rolls and Butter  
\*Poinsetta Salad  
\*Montrose Pudding  
\*Cocoanut Balls

## SUPPER

Potato Salad  
Lemonade  
Nut Bread Sandwiches  
\*Candied Strawberries

**MENUS ADAPTED TO THE FARM IN WINTER**

These menus are suggestive. If one article cannot be obtained substitutions may be made in foods of the same nature. It should be remembered that breakfast should be composed of fruit, cereal, meat or egg dish, bread and butter and beverage; dinner of meat or cheese dish, starchy vegetable, fresh or bulky vegetable, uncooked salad, either vegetable or fruit, bread and butter and dessert; and supper of a lighter meat, egg or cheese dish, one or two vegetables, a relish, bread and butter and some fruit or raw vegetable. Milk should be given to the children three times a day. At night it should take the place of meat eaten by older members of the family.

**MONDAY****BREAKFAST**

Fresh Apples  
Cracked Wheat  
Cream and Sugar  
Soft boiled eggs  
Bacon  
Toasted Biscuits and  
Butter  
Coffee, cream and sugar  
Milk for children

**DINNER**

Pot Roast  
Browned Potatoes  
Turnip Greens  
Cornbread and Butter  
Raw Onions  
Butter Milk  
Canned Grapes

**SUPPER**

Head Cheese  
Baked Potatoes  
Green Tomato Pickles  
Creamed Peas  
Bread and Butter  
Milk

**TUESDAY****BREAKFAST**

Canned Peaches  
Oat Meal  
Cream and Sugar  
Scrambled Eggs or Ham  
Toast and Butter  
Coffee, Cream, Sugar  
Milk for children

**DINNER**

Backbone  
Baked Sweet Potatoes  
String Beans  
Slaw  
Mixed Pickles  
Corn Muffins  
Apple Whip with Soft  
Custard

**SUPPER**

Vegetable and Meat  
Hash  
Corn Field Peas  
Corn Sticks and Butter  
Pear Preserves  
Milk

**WEDNESDAY****BREAKFAST**

Canned Blackberries  
Cream of Wheat  
Sugar and Cream  
Sausage and Gravy  
Biscuits and Butter  
Coffee—Milk for children

**DINNER**

Boiled Pigs Feet  
Creamed Cabbage  
(Cook only 20 min.  
without meat)  
Hominy  
Plum Jelly  
Whole Wheat Muffins  
Apple and Nut Salad  
Cookies and Sweet Milk

**SUPPER**

Macaroni and Cheese  
Spinach with Hard  
Boiled Egg  
Bread and Butter  
Lemon Pie  
Milk



## THURSDAY

## BREAKFAST

Pears, fresh or canned  
 Corn Meal Mush  
 Cream and Sugar or  
 Gravy  
 Steamed Spareribs and  
 Gravy  
 Muffins and Butter  
 Coffee  
 Milk for children

## DINNER

Baked Duck and Dressing  
 Apple Jelly  
 Creamed Potatoes  
 English Peas Buttered  
 Escalloped Tomatoes  
 Bread and Butter  
 Ginger Bread and Milk

## SUPPER

Baked Peppers stuffed  
 with left over duck  
 Grape Marmalade  
 Escalloped Potatoes  
 Celery  
 Biscuits and Butter  
 Milk

## FRIDAY

## BREAKFAST

Apple Sauce  
 Pettijohn, Cream and  
 Sugar  
 Omelet  
 Toast and Butter  
 Coffee  
 Milk for children

## DINNER

Baked Ham  
 Mashed Potatoes  
 Sauer Kraut  
 Young Green Mustard  
 Salad  
 Corn Sticks  
 Butter Milk  
 Canned Peaches with  
 Cream

## SUPPER

Baked Beans and Pork  
 Turnip Greens  
 Bread and Butter  
 Sorghum  
 Milk

## SATURDAY

## BREAKFAST

Plums (canned)  
 Cream of Wheat, Cream  
 and Sugar  
 Fried Ham and Gravy  
 Biscuits and Butter and  
 Sorghum  
 Coffee  
 Milk for Children

## DINNER

Boiled Shoulder, Bone  
 Turnips and Greens  
 Canned Corn  
 Raw Onions  
 Corn Pone  
 Bread Pudding with  
 Hard Sauce

## SUPPER

Cream of Tomato Soup  
 Toast  
 Peanut Loaf or Sliced  
 Cold Meat  
 Hashed Browned Potatoes  
 Jelly  
 Bread and Butter  
 Milk

## SUNDAY

## BREAKFAST

Cherries (canned)  
 Oatmeal  
 Pan Cakes and Bacon  
 Syrup and Butter  
 Coffee—Milk for  
 children

## DINNER

Baked Hen and Stuffing  
 Rice  
 Spinach  
 Tomato Pickles  
 Slaw  
 Hot Biscuits—Butter  
 Butter Cake—Peaches  
 Coffee—Milk for  
 children

## SUPPER

Chicken Sandwiches  
 Baked Apples with  
 Cream  
 Cake and Milk

## MENUS FOR THE FARM IN SUMMER

## MONDAY

## BREAKFAST

Fresh Peaches  
 Cream of Wheat  
 Cream and Sugar  
 Baked Eggs (Soft)  
 Muffins and Butter  
 Coffee and Milk

## DINNER

Bolled Salt Pork (cooked  
 separate from veg.  
 but served with it)  
 String Beans  
 New Potatoes  
 Corn Bread and Butter  
 Milk  
 Baked Custard

## SUPPER

\*Cheese Soufflé  
 Combination Salad  
 Biscuits and Butter  
 Preserves  
 Milk

## TUESDAY

## BREAKFAST

Strawberries  
 Cornflakes and Cream  
 Creamed Eggs on Toast  
 Bacon  
 Toast  
 Coffee and Milk

## DINNER

Fried Chicken  
 English Peas  
 Corn on the Cob  
 Radishes  
 Bread and Butter  
 Sponge Cake and Jelly  
 Milk

## SUPPER

Escaloped Eggs  
 Potato Cakes  
 Tomato and Cucumber  
 Salad  
 Muffins and Butter  
 Watermelon

## WEDNESDAY

## BREAKFAST

Blackberries  
 Grapenuts and Cream  
 Broiled Ham  
 Pan Cakes and Butter  
 • Sorghum  
 Coffee and Milk

## DINNER

Creamed New Potatoes  
 Baked Squash  
 Corn Pudding  
 Fresh Spinach  
 Lettuce and Onions  
 with Mayonnaise  
 Corn Bread and Butter  
 Cottage Cheese with  
 Fruit  
 Milk

## SUPPER

\*Turkish Pilaf  
 Potato Salad  
 Graham Bread and  
 Butter  
 Fruit Pie  
 Milk

## THURSDAY

## BREAKFAST

Cantaloupe  
 Cornmeal Mush  
 Fried Eggs  
 Biscuits and Butter  
 Preserves  
 Coffee and Milk

## DINNER

Chicken Pie  
 Jelly  
 Fresh Tomatoes with  
 French Dressing  
 String Beans  
 Corn Muffins  
 Watermelon

## SUPPER

Stewed Corn  
 \*Fried Green Tomatoes  
 Lettuce, Cottage Cheese,  
 Green Pepper Salad  
 Bread and Butter  
 Strawberry Short Cake  
 with Cream  
 Milk

**FRIDAY****BREAKFAST**

Berries  
 Krumbles and Cream  
 Soft Boiled Eggs  
 Bacon  
 Muffins and Butter  
 Grape Butter  
 Coffee and Milk

**DINNER**

English Peas  
 Mashed Potatoes  
 Boiled Okra and Tomatoes  
 Corn  
 Radishes and Lettuce  
 with Salad Dressing  
 Corn Bread and Butter  
 Rice Pudding  
 Milk

**SUPPER**

Salmon Loaf  
 Tomato and Peas in Sauce  
 Potatoes  
 Hot Biscuits and Butter  
 Jelly

**SATURDAY****BREAKFAST**

Peaches (uncooked)  
 Shredded Wheat Biscuits and Cream  
 Scrambled Eggs  
 Toast and Jelly  
 Coffee and Milk

**DINNER**

Soup made from Ham-bone with all kinds of vegetables  
 Corn Bread and Butter  
 Chocolate Pie  
 Buttermilk

**SUPPER**

Cold Boiled Ham  
 Grits  
 Vegetable Salad  
 Muffins and Butter  
 Blackberry Jam  
 Milk

**SUNDAY****BREAKFAST**

Cantaloupe  
 Rolled Oats and Cream  
 Omelet  
 Hot Biscuits and Butter  
 Strawberry Preserves  
 Coffee and Milk

**DINNER**

Broiled Chicken  
 Rice  
 Buttered Peas and Carrots  
 Hot Biscuits and Butter  
 Tomato and Lettuce  
 Salad  
 Ice Cream and Cake

**SUPPER**

Cold Chicken  
 Lettuce Sandwiches  
 Tomato Relish  
 Cake and Milk

**THE SCHOOL LUNCH****Packed at Home**

The first consideration is the receptacle. It should be clean, and sanitary, and allow the food to be ventilated. Those in common use are baskets, boxes, and tin pails. If a tin pail is used, punch some holes in the side just below the lid.

The food should be packed attractively so as to tempt the appetite when opened. Each article of food should be wrapped separately in wax paper. If a small thermos bottle can be afforded, it serves as a means of carrying milk, which is so necessary for the growing child. A folding cup and knife, fork, and spoon should be furnished in the lunch box.

The lunch may be made up of the following foods: sandwiches, stuffed eggs, custards, cookies, fruit (fresh, preserved, and dried), nuts, and milk, when a thermos bottle is supplied. The sandwiches offer an opportunity for much variety. The following are suggestions for making different types of sandwiches.

#### **Bread.**

Bread should be of good quality; 24 hours old. Use whole wheat, graham, white bread, and Boston brown bread. Muffins and biscuit are acceptable only when crisp.

#### **Fillings.**

Meat—chicken, beef, veal, ham, or mutton, either sliced or ground. If tough, it is better ground. When ground season with cream or salad dressing, pepper and salt.

Cheese—cottage cheese, American cheese (grated and mixed with cream).

Eggs—hard cooked, never fried, seasoned with salt, pepper, cream or salad dressing. Chopped celery or olives may be added.

Fruit—dates, figs, raisins, jelly, preserves, marmalade, jams.

## **SUGGESTIONS FOR HOT LUNCH**

### **Prepared at School**

Teachers are urged during the winter months to have one hot dish prepared at school to supplement the lunch brought from home by the children. The following are suggestions of dishes that may easily be prepared.

1. Cocoa.
2. Creamed soups (corn, potato, pea, bean, tomato).
3. Corn and potato chowder.
4. Escalloped potatoes.
5. Creamed eggs.
6. Macaroni and cheese.
7. Macaroni and tomato sauce.
8. Turkish Pilaf.

Recipes follow. In every case the amounts will serve twenty-five. A number 3 can holds approximately one quart of home canned vegetables. A number 10 can holds 6 lbs. 6 oz., and is about equal to three number 3 cans.

All measurements are level.

### **Recipes for the School Lunch**

#### **Cocoa**

1 c. Cocoa  
1 c. Sugar  
 $\frac{1}{2}$  t. Salt

6 c. Boiling Water  
4 qts. Milk

Mix cocoa, sugar, and salt well. Add boiling water; boil from three to five minutes. This cooks the starch in the cocoa and makes it easier to

digest. Add the milk slowly and set over pan of hot water to cook until ready to serve.

### Cream of Corn Soup

|                    |                         |
|--------------------|-------------------------|
| 1 Slice Salt Pork  | 1 c. Flour              |
| 6 c. Boiling Water | 2 T. Salt               |
| 3 qts. Milk        | 2 t. Celery Salt        |
| 6 c. Corn          | $\frac{1}{2}$ t. Pepper |

2 small onions

Cut salt pork in cubes and fry with thinly sliced onion till brown. (Use same dish in which the soup is to be made.) Add the corn and boiling water and simmer 15 minutes. Add the flour which has been mixed smooth with an equal amount of cold water and boil five minutes to cook the starch in the flour and stir constantly to prevent lumping and burning. Turn in the milk and bring to boiling point. Season and serve. The pork may be omitted and the onion browned in  $\frac{1}{2}$  cup of fat instead of the pork.

### Potato Soup

|                          |                        |
|--------------------------|------------------------|
| 15 Medium Sized Potatoes | 4 T. Fat               |
| 6 c. Boiling Water       | 3 T. Salt              |
| 2 Small Onions           | $\frac{1}{2}$ c. Flour |
| 3 qts. Milk              | 2 t. Celery Salt       |

Bit of Bayleaf

Peel potatoes, cut in small pieces, and cook till soft in 6 cups boiling salted water ( $1\frac{1}{2}$  teaspoons salt). Without draining, mash the potatoes, add the fat, thinly sliced onion and flour mixed smooth with equal parts of cold water and boil five minutes to cook starch in flour and stir constantly to prevent lumping and burning. Add the milk and bring to boiling point. Season and serve.

### Cream of Pea or Bean Soup

|                        |                              |
|------------------------|------------------------------|
| 2 c. Dry Peas or Beans | $\frac{2}{3}$ c. Flour       |
| 6 c. Boiling Water     | 4 t. Salt                    |
| 3 qts. Milk            | $\frac{1}{2}$ t. Celery Salt |
| $\frac{1}{2}$ c. Fat   | $\frac{1}{2}$ t. Pepper      |

1 Small Onion

Soak peas over night in cold water. Cook till tender, putting on before school in the morning. Drain and mash with potato masher. Add four cups boiling water to the pulp, also the finely sliced onion, fat and the flour mixed smooth with an equal amount of cold water and boil for five minutes to cook starch in flour. Stir constantly to prevent lumping and burning. Add the milk and bring to boiling point. Season and serve.

**Tomato Soup**

|                       |                         |
|-----------------------|-------------------------|
| 2 qt. Cans Tomatoes   | 1 c. Flour              |
| $\frac{1}{2}$ t. Salt | 3 qts. Milk             |
| 2 Small Onions        | $\frac{1}{2}$ t. Pepper |
| 1 c. Fat              | 1 t. Celery Salt        |

**Bit of Bayleaf**

Heat tomatoes and mash well with fork or potato masher. Add onion, salt, fat and flour mixed with equal amounts of cold water and boil five minutes to cook starch in flour and stir constantly to prevent lumping and burning. Scald milk in double boiler and just before serving turn hot tomato mixture gradually into the hot milk, stirring all the time to prevent curdling. Season and serve immediately.

**Corn and Potato Chowder**

|                                        |                      |
|----------------------------------------|----------------------|
| 6 c. Raw Potato cut in<br>small pieces | 4 oz. Salt Pork      |
| 1 qt. Canned Corn                      | 1 Onion chopped fine |
| 1 gal. Milk                            | 1 t. Celery Salt     |
| Salt to Taste                          | 1 t. Paprika         |

Cut the salt pork in small pieces and cook with onion until light brown. Add the potato and cook about ten minutes. Add the corn and the milk and cook until the potatoes are tender. Season and serve.

**Escalloped Potatoes**

|                         |                         |
|-------------------------|-------------------------|
| 4 lb White Potatoes     | 1 qt. Milk              |
| $\frac{1}{2}$ lb Butter | 2 T. Salt               |
| Flour                   | $\frac{1}{8}$ t. Pepper |

Cut cold or freshly cooked potatoes in slices of  $\frac{1}{2}$ -inch cubes. Place in baking dishes. Sprinkle layers lightly with flour and butter. Heat the milk, add rest of butter, salt and pepper. Pour over potatoes and bake until milk is well absorbed. Brown.

**Creamed Eggs**

|                         |                      |
|-------------------------|----------------------|
| 2 doz. Hard Cooked Eggs | 1 c. Buttered Crumbs |
| 1 qt. White Sauce       |                      |

Slice the eggs and place in large baking dish. Pour in white sauce in between layers of eggs. Cover with buttered crumbs. Bake until crumbs are brown.

**White Sauce (3 quarts)**

|                                |                               |
|--------------------------------|-------------------------------|
| $\frac{1}{2}$ lb Butter        | $\frac{1}{2}$ t. Pepper       |
| $1\frac{1}{2}$ c. Sifted Flour | $2\frac{1}{2}$ qt. Whole Milk |
| 2 T. Salt                      | 1 pt. Hot Water               |

Heat milk in double boiler. Heat butter in large saucepan, stirring with wooden spoon. When it bubbles, add flour salt and pepper which have been mixed together. Stir until perfectly smooth. Add gradually the water and hot milk stirring constantly. Allow the mixture to thicken and boil each time before adding milk. After milk is added, place sauce in double boiler.

**Macaroni and Cheese**

1 lb Macaroni

Hot Water

1 qt. White Sauce

1 lb Grated Cheese

1 T. Salt

Break macaroni in 1-in. pieces or use elbow macaroni. Cook in boiling salted water until soft, pour cold water over it to prevent pieces from adhering. Dissolve cheese in white sauce and add macaroni. Serve in vegetable dishes or baking dishes, cover with buttered crumbs and brown in oven.

**Macaroni and Tomato Sauce**

Cook macaroni as for Macaroni and Cheese. Serve with tomato sauce made like white sauce only substitute tomato juice for milk. Season with onion and pepper.

**Turkish Pilaf**

(See recipe on page 52 of bulletin.)

**Recipes for Family Meals****BAKED BANANAS**

6 Bananas

2 T. Melted Butter

1/3 c. Sugar

2 T. Lemon Juice

Remove skins from bananas and cut in halves lengthwise. Put in shallow baking dish. Mix butter, sugar, and lemon juice and baste bananas with one-half of the mixture. Bake twenty minutes in slow oven, basting during baking with remaining mixture.

**BAKED STUFFED EGG PLANT**

1 Egg Plant

1 1/2 c. Ham Stock

3/4 c. Bread Crumbs

1/4 c. Melted Butter

1 t. Lemon Juice

1/2 t. Salt

1 Egg

Wipe egg plant and cut in quarters, lengthwise. Remove pulp close to skin, leaving thin shells. Force pulp through chopper and drain; put in sauce pan with ham stock and boil twenty minutes. Add other ingredients. Fill shells with mixture, sprinkle with buttered crumbs and bake in hot oven fifteen minutes.

## BROWN BETTY AND HARD SAUCE

## Brown Betty

|                                |                                    |
|--------------------------------|------------------------------------|
| 3 Medium Sized Apples          | 1 c. Dry Bread Crumbs              |
| $\frac{1}{4}$ c. Butter        | $\frac{1}{4}$ c. Sugar             |
| $\frac{1}{2}$ t. Cinnamon      | Juice and Rind $\frac{1}{2}$ Lemon |
| $\frac{1}{4}$ c. Boiling Water |                                    |

Pare, quarter, core and slice the apples. Melt the butter and pour it, with the lemon juice, over the crumbs. Mix the cinnamon, grated lemon rind and sugar together. Butter a baking dish; put in alternate layers of apples and bread crumbs, sprinkling the apples with the sugar mixture, making the last layer of crumbs. Pour the water on before adding the last layer of crumbs; cover and bake for thirty minutes or until apples are soft; then uncover and brown the crumbs. Serve with Hard Sauce or Lemon Sauce.

## Hard Sauce

|                         |                     |
|-------------------------|---------------------|
| $\frac{1}{2}$ c. Butter | 1 c. Powdered Sugar |
| 1 t. Vanilla or         | Grated Nutmeg       |
| 1 T. Lemon Juice        |                     |

Cream the butter and add sugar gradually; then add flavoring. Beat well and shape in a mound on a glass dish. Grate a little nutmeg over top.

## CANDIED STRAWBERRIES

|              |             |
|--------------|-------------|
| 2 cups Sugar | 1 cup Water |
| Washed Fruit |             |

Boil the sugar and water until the syrup is brittle when dropped into cold water. Dip strawberries separately in the syrup and set in a cold place.

## COCOANUT BALLS

|                                    |                          |
|------------------------------------|--------------------------|
| Whites 11 Eggs                     | 1 t. Cream Tartar        |
| $1\frac{1}{2}$ c. Granulated Sugar | 1 c. Sifted Pastry Flour |
| 1 T. Flavoring                     |                          |

Beat the eggs until light; add the cream of tartar and beat to a stiff froth; then add the sugar gradually. Fold in the flour after it has been sifted five times; add the flavoring and pour into paper lined layer cake pans. Bake in slow oven forty-five or fifty minutes. When cool, cut in strips or balls and roll in plain boiled frosting and then in fresh shredded cocoanut. Put on platter to harden.

## CHEESE SOUFFLE

|                                |                       |
|--------------------------------|-----------------------|
| 2 t. Butter                    | $\frac{3}{4}$ t. Salt |
| 3 T. Flour                     | Yolks 3 Eggs          |
| $\frac{1}{2}$ c. Milk          | Whites 2 Eggs         |
| $\frac{1}{2}$ c. Grated Cheese | Paprika               |

Melt butter, add flour, and stir until well blended; pour milk in gradually. Bring to boiling point, then add cheese and salt. Put over hot water and add yolks of eggs, beaten until thick; cut and fold in whites of eggs, beaten until stiff. Put on lid and bake until firm.



## ARKANSAS AGRICULTURAL EXPERIMENT STATION

### COFFEE ICE CREAM AND CARAWAY SEED COOKIES

#### Ice Cream

|               |              |
|---------------|--------------|
| 1 qt. Cream   | 1½ c. Sugar  |
| 1½ c. Milk    | ¼ t. Salt    |
| 1/3 c. Coffee | Yolks 4 Eggs |

Scald milk with coffee, add 1 c. sugar; mix egg yolks, slightly beaten, with ¼ c. sugar and salt; combine mixtures, cook over hot water until thickened, add one cup cream, and let stand on back of range twenty-five minutes; cool, add remaining cream, and strain through double cheesecloth; freeze. Coffee Ice Cream may be served with Maraschino Cherries, or in halves of cantaloupes.

#### Cookies

|                    |                    |
|--------------------|--------------------|
| 1 c. Butter        | 2 T. Milk          |
| 1 c. Sugar         | ¼ t. Salt          |
| 2 Eggs             | 2 c. Bread Flour   |
| 1 t. Baking Powder | 1 T. Caraway Seeds |

Cream butter, and add sugar gradually, while beating constantly. Add one egg and beat, then add the other egg and continue the beating. Add the remaining ingredients. Toss on a floured board and pat and roll to ¼ inch thickness. Shape with a small round cutter, first dipped in flour. Arrange on a buttered sheet and bake in a moderate oven.

#### COLE SLAW

|                 |                      |
|-----------------|----------------------|
| 1 Small Cabbage | Cream Salad Dressing |
|-----------------|----------------------|

Select a small, heavy cabbage, take off outside leaves, and cut in quarters; with a sharp knife, slice very thinly. Soak in cold water until crisp, drain, dry between towels, and mix with Cream Salad Dressing. Add finely chopped green pepper or blanched almonds, if desired.

#### CREAM PUFFS

|                |               |
|----------------|---------------|
| 1 c. Hot Water | Pinch of Salt |
| ½ c. Butter    | 1 c. Flour    |
| 3 Eggs         |               |

Boil the water, butter, and salt; stir in dry flour while it is boiling and stir quickly until mass thickens. Stand aside to cool and when cool add eggs, stirring them in thoroughly. Drop mixture by tablespoons on buttered tins and bake from thirty to forty minutes in hot oven. When cool, cut open with sharp knife and fill with cream.

To make éclairs, spread the batter in long ovals and when done cover with chocolate frosting.

#### CREAM FOR PUFFS

|            |            |
|------------|------------|
| 1 c. Milk  | 1 Egg      |
| ½ c. Sugar | 3 T. Flour |

Put the milk on to heat in double boiler. Beat the egg with sugar. Add flour and hot milk. Return to double boiler. Stir over fire until it thickens. Cool and add vanilla.

## CUCUMBER CUPS

Cucumbers

Lettuce Leaves

Cream French Dressing

Pare cucumbers and remove a thick slice from each end. With a sharp pointed knif, make eight grooves at equal distances lengthwise of cucumber. Cut in pieces crosswise and remove some of the inside, leaving cups; then cut in thin slices crosswise, keeping the original shapes. Arrange on a nest of lettuce leaves and fill with French Cream Dressing.

## FRIED GREEN TOMATOES

3 large Tomatoes

Flour

Salt and Pepper

Butter or Crisco

Wash tomatoes; slice in one-half inch slices; sprinkle with salt and pepper, cover with flour and fry in small amount of fat until a delicate brown. Lay on hot platter. If desired, pour over them a cream sauce made from butter left in pan.

## HUNTINGTON SALAD WITH STUFFED DATES

Wipe, peel, and chill medium sized tomatoes, then cut in five vertical pieces, crosswise, not severing sections. Mash a cream cheese, moisten with French Dressing. Pour into timbale mould and chill thoroughly. Remove from mould, cut in one-fourth inch slices crosswise and fit between incisions in tomatoes. Serve in nests of crisp lettuce with French Dressing.

## Stuffed Dates

Remove seeds and stuff with chopped black walnuts, roll in sugar and serve with salad.

## JELLIED VEGETABLE SALAD

 $\frac{1}{2}$  c. Cabbage (shredded) $\frac{1}{4}$  c. Peas (cold, cooked) $\frac{1}{2}$  t. Salt $\frac{1}{3}$  c. Cucumber cubes

1 T. Granulated Gelatine

 $\frac{1}{4}$  c. Sugar $\frac{1}{4}$  c. Vinegar

2 T. Lemon Juice

 $\frac{1}{4}$  c. Beans (cold, cooked) $\frac{1}{2}$  c. Beets (cold, cooked)

Soak gelatine in  $\frac{1}{4}$  cup cold water and dissolve in one cup boiling water; then add sugar and vinegar, lemon juice and salt. Strain, cool and when beginning to stiffen add vegetables. Turn into ring mould and chill. Remove to serving dish and arrange around jelly thin slices of cold cooked meat. Fill center with Horseradish Cream Dressing and garnish with water cress.

## HORSERADISH CREAM DRESSING

 $\frac{1}{2}$  c. Heavy Cream

3 T. Vinegar

 $\frac{1}{4}$  t. Salt

Few grains Pepper

2 T. Grated Horseradish Root

Beat cream until it begins to thicken; then add vinegar gradually. When mixture is stiff, add seasoning and fold in grated horseradish.

## JELLY ROLL WITH CREAM

Cut jelly roll in one-half inch slices. Line a charlotte rousse mould or tea-cup with slices and fill with Bavarian Cream.

## JELLY ROLL

Beat yolks of four eggs and add 3 T. cold water; then add gradually, while beating, one cup sugar. Put  $1\frac{1}{2}$  T. cornstarch in cup and fill with flour. Mix and sift  $1\frac{1}{4}$  t. baking powder and add to first mixture; then add whites of four eggs beaten until stiff, and one t. lemon extract. Turn in greased pan and bake in a moderate oven. Remove from pan to cloth dredged with Confectioner's Sugar. Spread with apple jelly which has been beaten with a silver fork until of right consistency to spread evenly. Trim off edges and roll as quickly as possible while hot.

## STRAWBERRY BAVARIAN CREAM

Soak  $1\frac{1}{2}$  T. granulated gelatine in  $\frac{1}{4}$  c. cold water and dissolve in  $\frac{1}{4}$  c. boiling water. Add 1 c. syrup drained from can of strawberries and more sugar if needed. Color pink. Set bowl in ice water until mixture thickens, then fold in 1 pint heavy cream, beaten until stiff.

## MARSHMALLOW GINGERBREAD

|                             |                          |
|-----------------------------|--------------------------|
| 1 t. Salt                   | 1 t. Ginger              |
| $\frac{1}{2}$ c. Shortening | 1 c. Molasses            |
| 1 Egg                       | 2 $\frac{1}{3}$ c. Flour |
| 1 t. Soda                   | 2 t. Baking Powder       |
| 1 c. Sour Milk              | Marshmallows             |

Melt shortening (chicken fat may be used) and add molasses, egg, well beaten, flour mixed and sifted with soda, salt, ginger, and sour milk. Beat vigorously, turn into a buttered and floured pan and bake in moderate oven twenty-five minutes. Remove from pan, cut in halves crosswise and put marshmallows between layers. Put in oven and let stand three minutes. Remove to serving dish, cool slightly, cut in squares, and serve with whipped cream, sweetened and flavored with vanilla.

## MONTROSE PUDDING

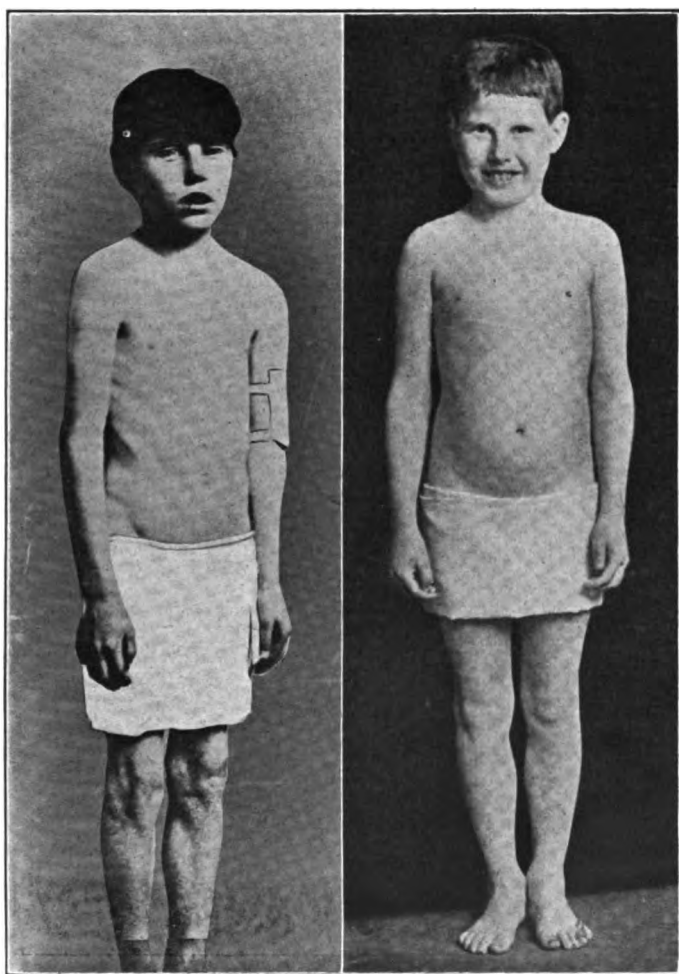
Line a mould with lemon ice, fill with maraschino cream, cover with buttered paper, adjust cover, pack in salt and ice, using one part salt and two parts ice, and let stand three hours. Remove to serving dish and garnish with Maraschino Cream forced through pastry tube or bag, and candied cherries.

**LEMON ICE**—Make a syrup by boiling 4 cups water and 2 cups sugar five minutes. Add  $\frac{1}{4}$  c. lemon juice, cool, strain, and freeze.

**MARASCHINO CREAM**—Beat one pint heavy cream until stiff. Add  $\frac{1}{2}$  c. Powdered Sugar, two T. Maraschino juice, and a few grains salt.

## MARSHMALLOW TEAS

Arrange marshmallows on thin unsweetened round wafer crackers, allowing one marshmallow to each cracker. Make a deep impression in the center of each marshmallow and in each cavity drop  $\frac{1}{4}$  t. butter. Arrange on a thin sheet and bake until marshmallows spread and nearly cover crackers. Insert  $\frac{1}{2}$  a candied cherry in each cavity and serve with a salad or afternoon tea.



#### MENTAL RETARDATION OR MENTAL DEFICIENCY

Tom was 11 per cent underweight, a mouth breather, with round shoulders, flat chest, spinal curvature, and flabby muscles. He was considered stupid, and kept after school in a vain attempt to hold him up to his grade. The right half of the picture shows him after his diseased adenoids and tonsils had been removed and he had followed directions as to diet and rest. The transformation in his condition can be seen to be mental as well as physical.

(From Emerson's "Nutrition and Growth in Children".  
Courtesy of D. Appleton and Company.)



The scales tell the story. All children should be weighed and measured regularly; weight should be taken with indoor clothing, preferably without shoes, and at the same hour of the day. To secure correct height, make certain the child is standing erect and that the measuring rod is held at a right angle to the upright.

## NUT LOAF

|                      |                                     |
|----------------------|-------------------------------------|
| 1 c. Hot Boiled Rice | 1 c. Pecan Nut Meats finely chopped |
| 1 c. Cracked Crumbs  | 1 Egg                               |
| 1 c. Milk            | 1½ t. Salt                          |
| ¼ t. Pepper          | 1 T. melted Butter                  |

Mix rice, nuts, and cracker crumbs; then add well beaten egg, milk, salt, and pepper. Turn into buttered pan; pour over butter; cover and bake in a moderate oven one hour. Turn on hot platter and pour on the following sauce: cook 3 T. butter with 2 slices onion three minutes, stirring constantly. Add 3 T. flour and stir until well blended; then pour on gradually, while stirring, 1½ c. milk. Bring to boiling point and add ½ t. salt, and a few grains pepper and strain.

## ORANGE STAR SALAD

On individual plates of lettuce arrange, in star pattern, five sections of orange, free from membrane. Cut long slender strips of figs and place on edge of orange sections; fill spaces between orange star points with finely-cut dates. Serve with French Dressing.

## PEANUT SALAD SANDWICHES

To any amount of Commercial Peanut Butter add ½ the quantity of chili sauce and ½ the quantity of thick cooked salad dressing. If desired, add ½ cup of fine chopped celery. Make into a paste and spread on thin buttered slices of bread.

## PINEAPPLE JELLY

|                        |                  |
|------------------------|------------------|
| 2 c. Boiling Water     | ½ c. Sugar       |
| 1 c. Pineapple Juice   | 3 T. Lemon Juice |
| 2 T. Gelatine          | 2 T. cold Water  |
| 1/3 c. Pineapple Cubes |                  |

Pour boiling water over sugar, and when sugar has dissolved, add gelatine soaked in cold water five minutes; then add juice drained from canned pineapple and lemon juice and strain. When mixture begins to thicken, add canned pineapple, turn into a mould, first dipped in cold water, and chill thoroughly.

## PINEAPPLE WHIP

|                    |                                     |
|--------------------|-------------------------------------|
| 1 qt. Double Cream | 1 No. 2 Can Broken Sliced Pineapple |
| ¾ to 1 c. Sugar    | Salt                                |
| ½ lb. Marshmallows |                                     |

Drain pineapple and cut slices into small pieces. Cut marshmallows into small pieces. Whip cream, fold in sugar, add marshmallows and pineapple. Serve chilled with crisp wafers.

## POINSETTA SALAD

Chill six small tomatoes of uniform size. Peel and cut in eighths without severing sections. Open in such fashion as to represent the petals of flowers. In center of each place a T. cream cheese, moistened with French Dressing, seasoned with paprika. Serve with French Dressing.

## SHIRRED EGGS

Butter muffin tins; cover bottom and sides with fine cracker crumbs. Break an egg and carefully slip into each muffin cup. Cover with seasoned buttered crumbs. Bake in moderate oven until white is hard and crumbs are brown. Eggs may be baked in small tomatoes—scoop out the pulp, slip in egg, sprinkle with salt, pepper, bread crumbs, and bake.

## SPRING SALAD

Cut four hard boiled eggs in halves crosswise, remove yolks and cut a thin slice from each end of whites, thus making cups that will stand upright. Mash yolks and moisten with cream salad dressing. Fill cups with  $\frac{1}{2}$  cup tiny cucumber cubes mixed with three T. chopped sweet cucumber pickles and moisten with salad dressing. Garnish top of each with yolk mixture, forced through a pastry bag. Arrange thick slices of tomato on lettuce leaves and on each slice of tomato place an egg cup. Garnish with water cress.

## STRAWBERRY SALAD

Wash, hull, and cut one pint of selected strawberries in halves lengthwise. Sprinkle with powdered sugar. Cover and let stand on ice until thoroughly chilled. Arrange in eight nests of white lettuce leaves and cover fruit with  $\frac{1}{2}$  pint whipped cream (seasoned with salt and paprika) to which has been added  $\frac{1}{2}$  cup mayonnaise dressing. Garnish with halves of strawberries and chopped nuts.

## TURKISH PILAF

|                                           |                                    |
|-------------------------------------------|------------------------------------|
| 1 c. Raw Rice                             | 1 $\frac{1}{3}$ c. Canned or Fresh |
| 4 c. Water                                | Tomatoes                           |
| 1 t. Salt                                 | Seasoning (onions and green        |
| $\frac{1}{4}$ c. small pieces fried Bacon | peppers)                           |
| 1 T. Butter                               |                                    |

Cook rice, add other ingredients, put in baking dish and bake ten minutes.

## VEAL BIRDS

Wipe slices of veal from leg, cut as thinly as possible, then remove bone, skin, and fat. Pound until  $\frac{1}{4}$  inch thick and cut in pieces  $2\frac{1}{2}$  inches long by  $1\frac{1}{4}$  inches wide, each piece making a bird. Chop trimmings of meat, adding for every three birds a piece of fat salt pork cut 1 inch square and  $\frac{1}{4}$  inch thick—pork also to be chopped. Add to trimmings and pork  $\frac{1}{2}$  measure of cracker crumbs and season highly with salt, pepper, lemon and onion juice. Moisten with egg and hot water or stock. Spread each piece with thin layer of mixture and avoid having it close to edge. Roll and fasten with skewers. Sprinkle with salt and pepper, dredge with flour and fry in hot fat until a golden brown. Put in stew pan, add cream to half cover meat, cook slowly twenty minutes, or until tender. Serve on small pieces of toast, straining cream remaining in pan over birds and toast and garnish with parsley. A thin white sauce in place of cream may be served around birds.

## WILTED LETTUCE

Wash  $\frac{1}{2}$  lb. of crisp lettuce, shred with scissors, and place in covered vegetable bowl. Cut three slices of bacon in small cubes and fry it; to this add  $\frac{1}{3}$  cup of vinegar,  $\frac{1}{3}$  c. hot water, salt, pepper, and a little grated onion. Bring all to a boil and pour over lettuce. Let stand covered ten minutes, then serve.

### RELATIVE VITAMIN AND PROTEIN VALUES OF OUR MORE COMMON FOODS

The table given below, adapted from several other similar tables, and modified to include the results of recent investigations, shows the relative vitamin and protein values of our common foods so far as they are known. Although the values given are only approximate, the table provides a quick reference and will help in choosing the best food combinations for supplying the necessary vitamin and protein requirements.

| ARTICLE                               | A        | B       | C        | PROTEIN |
|---------------------------------------|----------|---------|----------|---------|
| Almonds -----                         | Poor     | Good    | Unknown  | Fair    |
| Apples -----                          | Poor     | Poor    | Fair     |         |
| Bananas -----                         | Little   | Little  | Fair     |         |
| Barley, whole -----                   | Poor     | Good    | Trace    | Poor    |
| Beans, kidney -----                   | Unknown  | Rich    | Unknown  | Poor    |
| Beans, navy -----                     | Unknown  | Rich    | Trace    | Poor    |
| Beans, soy -----                      | Poor     | Rich    | Trace    | Fair    |
| Beans, sprouted -----                 | Unknown  | Unknown | Good     |         |
| Beans, string, fresh ---              | Good     | Good    | Good     |         |
| Beef fat -----                        | Fair     | Trace   | Trace    |         |
| Beets -----                           | Fair     | Fair    | Fair     |         |
| Brains -----                          | Fair     | Good    | Little   |         |
| Brazil nuts -----                     | Unknown  | Good    | Unknown  |         |
| Bread, white (water) -                | Doubtful | Little  | Doubtful |         |
| Bread, white (milk) --                | Poor     | Poor    | Doubtful |         |
| Bread, whole wheat<br>(water -----    | Poor     | Good    | Doubtful | Fair    |
| Bread, whole wheat<br>(milk) -----    | Good     | Good    | Doubtful | Fair    |
| Butter -----                          | Rich     | Trace   | Trace    |         |
| Buttermilk -----                      | Poor     | Good    | Poor     |         |
| Cabbage, cooked (20<br>minutes) ----- | Good     | Good    | Fair     |         |
| Cabbage, green -----                  | Good     | Good    | Rich     |         |
| Carrots, fresh raw ----               | Good     | Good    | Fair     |         |



| ARTICLE                  | A         | B       | C       | PROTEIN   |
|--------------------------|-----------|---------|---------|-----------|
| Carrots, cooked -----    | Good      | Fair    | Poor    |           |
| Cauliflower -----        | Poor      | Good    | Poor    |           |
| Celery -----             | Unknown   | Good    | Unknown |           |
| Chard -----              | Good      | Fair    | Unknown |           |
| Cheese -----             | Good      | Little  | Unknown | Good      |
| Chestnut -----           | Unknown   | Good    | Unknown |           |
| Cocoanut -----           | Poor      | Good    | Unknown |           |
| Cocoanut oil -----       | Trace     | Trace   | Trace   |           |
| Codliver oil -----       | Very rich | Trace   | Trace   |           |
| Corn, white -----        | Trace     | Good    | Trace   | Poor      |
| Corn, yellow -----       | Fair      | Good    | Trace   | Poor      |
| Corn oil -----           | Little    | Trace   | Trace   |           |
| Cottage cheese -----     | Poor      | Little  | Unknown | Excellent |
| Cottonseed oil -----     | Little    | Trace   | Trace   |           |
| Cream -----              | Excellent | Little  | Trace   |           |
| Cress -----              | Unknown   | Unknown | Poor    |           |
| Cucumber -----           | Unknown   | Poor    | Unknown |           |
| Dandelion greens -----   | Good      | Fair    | Poor    |           |
| Dasheens -----           | Trace     | Poor    | Poor    |           |
| Eggplant (dried) -----   | Unknown   | Good    | Unknown |           |
| Eggs -----               | Good      | Fair    | Poor    | Good      |
| Endive -----             | Poor      | Unknown | Poor    |           |
| Filberts -----           | Unknown   | Good    | Unknown | Fair      |
| Fish -----               | Trace     | Poor    | Unknown | Excellent |
| Grains, sprouted -----   | Poor      | Fair    | Good    |           |
| Grapefruit -----         | Unknown   | Good    | Good    |           |
| Grapes -----             | Unknown   | Poor    | Poor    |           |
| Grape juice -----        | Unknown   | Poor    | Poor    |           |
| Heart -----              | Fair      | Fair    | Little  |           |
| Hickory nuts -----       | Unknown   | Good    | Unknown |           |
| Kidney -----             | Good      | Good    | Little  |           |
| Lard -----               | Little    | Trace   | Trace   |           |
| Lemon juice -----        | Unknown   | Good    | Rich    |           |
| Lettuce -----            | Good      | Good    | Rich    |           |
| Limes -----              | Unknown   | Poor    | Poor    |           |
| Liver -----              | Good      | Good    | Fair    |           |
| Mango -----              | Unknown   | Unknown | Poor    |           |
| Margarine, nut -----     | Trace     | Trace   | Trace   |           |
| Margarine, oleo -----    | Poor      | Trace   | Trace   |           |
| Meat (muscle) -----      | Trace     | Little  | Little  | Excellent |
| Meat extract -----       | Trace     | Trace   | Trace   |           |
| Meat, canned -----       | Trace     | Slight  | Trace   | Good      |
| Milk -----               | Rich      | Good    | Fair    | Excellent |
| Milk, condensed -----    | Rich      | Good    | Poor    |           |
| Milk, dried, whole ----- | Rich      | Good    | Poor    | Excellent |
| Milk, dried, skim -----  | Fair      | Good    | Poor    | Excellent |

| ARTICLE                                       | A       | B       | C       | PROTEIN |
|-----------------------------------------------|---------|---------|---------|---------|
| Mulberries .....                              | Unknown | Unknown | Poor    |         |
| Mutton fat .....                              | Poor    | Trace   | Trace   |         |
| Oats .....                                    | Poor    | Good    | Trace   | Poor    |
| Olive oil .....                               | Trace   | Trace   | Trace   |         |
| Onions .....                                  | Unknown | Good    | Good    |         |
| Orange juice .....                            | Poor    | Good    | Rich    |         |
| Orange peel .....                             | Poor    | Poor    | Good    |         |
| Parsnips .....                                | Poor    | Good    | Unknown |         |
| Pancreas .....                                | Poor    | Rich    | Unknown |         |
| Peanut oil .....                              | Trace   | Trace   | Trace   |         |
| Peanuts .....                                 | Poor    | Good    | Unknown | Fair    |
| Pears .....                                   | Unknown | Poor    | Fair    |         |
| Peas, green .....                             | Good    | Good    | Poor    | Poor    |
| Peas, sprouted .....                          | Unknown | Unknown | Good    |         |
| Pecans .....                                  | Unknown | Fair    | Unknown |         |
| Pig kidney fat .....                          | Good    | Trace   | Trace   |         |
| Pine nuts .....                               | Poor    | Fair    | Unknown | Fair    |
| Potatoes, sweet .....                         | Good    | Fair    | Unknown |         |
| Potatoes, white, boiled<br>(15 minutes) ..... | Little  | Fair    | Fair    | Poor    |
| Potatoes, white, boiled<br>(1 hour) .....     | Little  | Fair    | Poor    | Poor    |
| Potatoes, white, baked                        | Little  | Fair    | Poor    | Poor    |
| Prunes .....                                  | Unknown | Poor    | Trace   |         |
| Radish .....                                  | Unknown | Poor    | Unknown |         |
| Raisins .....                                 | Unknown | Good    | Unknown |         |
| Raspberries .....                             | Unknown | Unknown | Rich    |         |
| Raspberries, canned                           | Unknown | Unknown | Rich    |         |
| Rhubarb .....                                 | Unknown | Unknown | Fair    |         |
| Rice, polished .....                          | Trace   | Trace   | Trace   | Poor    |
| Rice whole grain .....                        | Poor    | Good    | Trace   | Fair    |
| Roe, fish .....                               | Poor    | Good    | Little  |         |
| Rutabaga .....                                | Little  | Good    | Rich    |         |
| Rye, whole .....                              | Poor    | Good    | Trace   | Fair    |
| Sauerkraut .....                              | Unknown | Unknown | Trace   |         |
| Spinach, fresh .....                          | Rich    | Rich    | Good    |         |
| Spinach, dried .....                          | Rich    | Rich    | Good    |         |
| Squash, Hubbard .....                         | Good    | Unknown | Unknown |         |
| Sweetbreads .....                             | Poor    | Poor    | Unknown |         |
| Tomatoes, raw .....                           | Good    | Rich    | Rich    |         |
| Tomatoes, canned                              | Good    | Rich    | Rich    |         |
| Turnips .....                                 | Fair    | Good    | Unknown |         |
| Walnuts, black .....                          | Unknown | Good    | Unknown | Fair    |
| Walnuts, English .....                        | Unknown | Good    | Unknown | Fair    |
| Yeast .....                                   | Absent  | Rich    | Absent  | Good    |

TABLE I.—AVERAGE STATURES AND WEIGHTS, FROM BIRTH TO 6 YEARS, BY AGES; WHITE CHILDREN. (Without Clothing).\*

| Age                      | Boys                     |                         | Girls                    |                         |
|--------------------------|--------------------------|-------------------------|--------------------------|-------------------------|
|                          | Average stature (inches) | Average weight (pounds) | Average stature (inches) | Average weight (pounds) |
| Under 1 month.....       | 21.16                    | 9.11                    | 20.89                    | 8.65                    |
| 1 month, under 2.....    | 22.47                    | 10.88                   | 21.92                    | 10.14                   |
| 2 months, under 3.....   | 23.58                    | 12.61                   | 23.09                    | 11.71                   |
| 3 months, under 4.....   | 24.55                    | 14.07                   | 24.00                    | 13.03                   |
| 4 months, under 5.....   | 25.38                    | 15.37                   | 24.83                    | 14.25                   |
| 5 months, under 6.....   | 26.10                    | 16.50                   | 25.53                    | 15.32                   |
| 6 months, under 7.....   | 26.72                    | 17.47                   | 26.15                    | 16.26                   |
| 7 months, under 8.....   | 27.27                    | 18.31                   | 26.70                    | 17.09                   |
| 8 months, under 9.....   | 27.76                    | 19.04                   | 27.20                    | 17.81                   |
| 9 months, under 10.....  | 28.21                    | 19.68                   | 27.66                    | 18.45                   |
| 10 months, under 11..... | 28.64                    | 20.27                   | 28.10                    | 19.03                   |
| 11 months, under 12..... | 29.06                    | 20.81                   | 28.51                    | 19.56                   |
| 12 months, under 13..... | 29.47                    | 21.32                   | 28.91                    | 20.04                   |
| 13 months, under 14..... | 29.87                    | 21.82                   | 29.30                    | 20.51                   |
| 14 months, under 15..... | 30.26                    | 22.31                   | 29.69                    | 20.96                   |
| 15 months, under 16..... | 30.64                    | 22.78                   | 30.08                    | 21.42                   |
| 16 months, under 17..... | 31.02                    | 23.25                   | 30.47                    | 21.88                   |
| 17 months, under 18..... | 31.39                    | 23.72                   | 30.86                    | 22.35                   |
| 18 months, under 19..... | 31.76                    | 24.18                   | 31.24                    | 22.81                   |
| 19 months, under 20..... | 32.11                    | 24.62                   | 31.60                    | 23.26                   |
| 20 months, under 21..... | 32.44                    | 25.04                   | 31.93                    | 23.68                   |
| 21 months, under 22..... | 32.76                    | 25.45                   | 32.24                    | 24.07                   |
| 22 months, under 23..... | 33.06                    | 25.84                   | 32.53                    | 24.45                   |
| 23 months, under 24..... | 33.34                    | 26.21                   | 32.81                    | 24.81                   |
| 24 months, under 25..... | 33.62                    | 26.58                   | 33.09                    | 25.17                   |
| 25 months, under 26..... | 33.89                    | 26.95                   | 33.37                    | 25.54                   |
| 26 months, under 27..... | 34.16                    | 27.31                   | 33.66                    | 25.92                   |
| 27 months, under 28..... | 34.43                    | 27.68                   | 33.95                    | 26.31                   |
| 28 months, under 29..... | 34.71                    | 28.06                   | 34.24                    | 26.70                   |
| 29 months, under 30..... | 34.99                    | 28.45                   | 34.53                    | 27.09                   |
| 30 months, under 31..... | 35.27                    | 28.83                   | 34.82                    | 27.48                   |
| 31 months, under 32..... | 35.54                    | 29.20                   | 35.09                    | 27.85                   |
| 32 months, under 33..... | 35.79                    | 29.56                   | 35.34                    | 28.20                   |
| 33 months, under 34..... | 36.02                    | 29.88                   | 35.58                    | 28.54                   |
| 34 months, under 35..... | 36.24                    | 30.18                   | 35.81                    | 28.88                   |
| 35 months, under 36..... | 36.46                    | 30.47                   | 36.03                    | 29.20                   |
| 36 months, under 37..... | 36.67                    | 30.75                   | 36.25                    | 29.51                   |
| 37 months, under 38..... | 36.89                    | 31.04                   | 36.48                    | 29.82                   |
| 38 months, under 39..... | 37.11                    | 31.34                   | 36.72                    | 30.13                   |
| 39 months, under 40..... | 37.34                    | 31.67                   | 36.96                    | 30.46                   |
| 40 months, under 41..... | 37.57                    | 32.01                   | 37.21                    | 30.79                   |
| 41 months, under 42..... | 37.81                    | 32.36                   | 37.46                    | 31.12                   |
| 42 months, under 43..... | 38.05                    | 32.71                   | 37.70                    | 31.44                   |
| 43 months, under 44..... | 38.29                    | 33.05                   | 37.92                    | 31.73                   |
| 44 months, under 45..... | 38.51                    | 33.36                   | 38.13                    | 32.00                   |
| 45 months, under 46..... | 38.72                    | 33.65                   | 38.33                    | 32.27                   |
| 46 months, under 47..... | 38.91                    | 33.91                   | 38.52                    | 32.53                   |
| 47 months, under 48..... | 39.09                    | 34.14                   | 38.70                    | 32.78                   |
| 48 months, under 49..... | 39.25                    | 34.36                   | 38.89                    | 33.05                   |
| 49 months, under 50..... | 39.42                    | 34.59                   | 39.08                    | 33.31                   |
| 50 months, under 51..... | 39.59                    | 34.82                   | 39.27                    | 33.57                   |
| 51 months, under 52..... | 39.77                    | 35.06                   | 39.47                    | 33.85                   |

TABLE I.—AVERAGE STATURES AND WEIGHTS, FROM BIRTH TO 6 YEARS, BY AGES; WHITE CHILDREN. (Without Clothing).

(Continued)

| Age                      | Boys                     |                         | Girls                    |                         |
|--------------------------|--------------------------|-------------------------|--------------------------|-------------------------|
|                          | Average stature (inches) | Average weight (pounds) | Average stature (inches) | Average weight (pounds) |
| 52 months, under 53..... | 39.96                    | 35.33                   | 39.69                    | 34.17                   |
| 53 months, under 54..... | 40.18                    | 35.63                   | 39.91                    | 34.48                   |
| 54 months, under 55..... | 40.40                    | 35.94                   | 40.14                    | 34.81                   |
| 55 months, under 56..... | 40.62                    | 36.27                   | 40.36                    | 35.14                   |
| 56 months, under 57..... | 40.83                    | 36.61                   | 40.58                    | 35.45                   |
| 57 months, under 58..... | 41.03                    | 36.94                   | 40.79                    | 35.75                   |
| 58 months, under 59..... | 41.22                    | 37.28                   | 40.98                    | 36.05                   |
| 59 months, under 60..... | 41.40                    | 37.60                   | 41.16                    | 36.35                   |
| 60 months, under 61..... | 41.57                    | 37.91                   | 41.34                    | 36.65                   |
| 61 months, under 62..... | 41.75                    | 38.20                   | 41.52                    | 36.94                   |
| 62 months, under 63..... | 41.93                    | 38.48                   | 41.69                    | 37.23                   |
| 63 months, under 64..... | 42.11                    | 38.75                   | 41.86                    | 37.52                   |
| 64 months, under 65..... | 42.31                    | 39.05                   | 42.03                    | 37.80                   |
| 65 months, under 66..... | 42.51                    | 39.36                   | 42.20                    | 38.09                   |
| 66 months, under 67..... | 42.71                    | 39.69                   | 42.38                    | 38.42                   |
| 67 months, under 68..... | 42.91                    | 40.03                   | 42.58                    | 38.74                   |
| 68 months, under 69..... | 43.10                    | 40.39                   | 42.81                    | 39.14                   |
| 69 months, under 70..... | 43.32                    | 40.72                   | 43.03                    | 39.53                   |
| 70 months, under 71..... | 43.48                    | 41.17                   | 43.39                    | 40.17                   |
| 71 months, under 72..... | 43.87                    | 41.40                   | 43.52                    | 40.36                   |

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TABLE II. AVERAGE HEIGHT AND WEIGHT OF BOYS AT DIFFERENT AGES

| Height<br>Inches | 5<br>yrs. | 6<br>yrs. | 7<br>yrs. | 8<br>yrs. | 9<br>yrs. | 10<br>yrs. | 11<br>yrs. | 12<br>yrs. | 13<br>yrs. | 14<br>yrs. | 15<br>yrs. | 16<br>yrs. | 17<br>yrs. | 18<br>yrs. |
|------------------|-----------|-----------|-----------|-----------|-----------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| 39               | 35        | 36        | 37        |           |           |            |            |            |            |            |            |            |            |            |
| 40               | 37        | 38        | 39        |           |           |            |            |            |            |            |            |            |            |            |
| 41               | 39        | 40        | 41        |           |           |            |            |            |            |            |            |            |            |            |
| 42               | 41        | 42        | 43        | 44        |           |            |            |            |            |            |            |            |            |            |
| 43               | 43        | 44        | 45        | 46        |           |            |            |            |            |            |            |            |            |            |
| 44               | 45        | 46        | 46        | 47        |           |            |            |            |            |            |            |            |            |            |
| 45               | 47        | 47        | 48        | 48        | 49        |            |            |            |            |            |            |            |            |            |
| 46               | 48        | 49        | 50        | 50        | 51        |            |            |            |            |            |            |            |            |            |
| 47               | ---       | 51        | 52        | 52        | 53        | 54         |            |            |            |            |            |            |            |            |
| 48               | ---       | 53        | 54        | 55        | 55        | 56         | 57         |            |            |            |            |            |            |            |
| 49               | ---       | 55        | 56        | 57        | 58        | 58         | 59         |            |            |            |            |            |            |            |
| 50               | ---       | ---       | 58        | 59        | 60        | 60         | 61         | 62         |            |            |            |            |            |            |
| 51               | ---       | ---       | 60        | 61        | 62        | 63         | 64         | 65         |            |            |            |            |            |            |
| 52               | ---       | ---       | 62        | 63        | 64        | 65         | 67         | 68         |            |            |            |            |            |            |
| 53               | ---       | ---       | ---       | 66        | 67        | 68         | 69         | 70         | 71         |            |            |            |            |            |
| 54               | ---       | ---       | ---       | 69        | 70        | 71         | 72         | 73         | 74         |            |            |            |            |            |
| 55               | ---       | ---       | ---       | ---       | 73        | 74         | 75         | 76         | 77         | 78         |            |            |            |            |
| 56               | ---       | ---       | ---       | ---       | 77        | 78         | 79         | 80         | 81         | 82         |            |            |            |            |
| 57               | ---       | ---       | ---       | ---       | ---       | 81         | 82         | 83         | 84         | 85         | 86         |            |            |            |
| 58               | ---       | ---       | ---       | ---       | ---       | 84         | 85         | 86         | 87         | 88         | 90         | 91         |            |            |
| 59               | ---       | ---       | ---       | ---       | ---       | 87         | 88         | 89         | 90         | 92         | 94         | 96         | 97         |            |
| 60               | ---       | ---       | ---       | ---       | ---       | 91         | 92         | 93         | 94         | 97         | 99         | 101        | 102        |            |
| 61               | ---       | ---       | ---       | ---       | ---       | ---        | 95         | 97         | 99         | 102        | 104        | 106        | 108        | 110        |
| 62               | ---       | ---       | ---       | ---       | ---       | ---        | 100        | 102        | 104        | 106        | 109        | 111        | 113        | 116        |
| 63               | ---       | ---       | ---       | ---       | ---       | ---        | 105        | 107        | 109        | 111        | 114        | 115        | 117        | 119        |
| 64               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | 113        | 115        | 117        | 118        | 119        | 120        | 122        |
| 65               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | 120        | 122        | 123        | 124        | 125        | 126        |
| 66               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | 125        | 126        | 127        | 128        | 129        | 130        |
| 67               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | 130        | 131        | 132        | 133        | 134        | 135        |
| 68               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | 134        | 135        | 136        | 137        | 138        | 139        |
| 69               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | 138        | 139        | 140        | 141        | 142        | 143        |
| 70               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | ---        | 142        | 144        | 145        | 146        | 147        |
| 71               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | ---        | 147        | 149        | 150        | 151        | 152        |
| 72               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | ---        | 152        | 154        | 155        | 156        | 157        |
| 73               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | ---        | 157        | 159        | 160        | 161        | 162        |
| 74               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | ---        | 162        | 164        | 165        | 166        | 167        |
| 75               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | ---        | ---        | 169        | 170        | 171        | 172        |
| 76               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | ---        | ---        | 174        | 175        | 176        | 177        |

Tables by Dr. Thomas D. Wood, Professor of Physical Education, Teachers College, Columbia University.

About what a boy should gain each month.

| Age           | Age    |
|---------------|--------|
| 5 to 8.....   | 6 oz.  |
| 8 to 12.....  | 8 oz.  |
| 12 to 14..... | 12 oz. |
| 14 to 16..... | 16 oz. |
| 16 to 18..... | 8 oz.  |

Height and weight to be taken in house clothes, without shoes. Weigh on the same date each month, about the same hour of the day. Age, the nearest birthday.

TABLE III. AVERAGE HEIGHT AND WEIGHT OF GIRLS AT DIFFERENT AGES

| Height<br>Inches | 5<br>yrs. | 6<br>yrs. | 7<br>yrs. | 8<br>yrs. | 9<br>yrs. | 10<br>yrs. | 11<br>yrs. | 12<br>yrs. | 13<br>yrs. | 14<br>yrs. | 15<br>yrs. | 16<br>yrs. | 17<br>yrs. | 18<br>yrs. |
|------------------|-----------|-----------|-----------|-----------|-----------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| 39               | 34        | 35        | 36        |           |           |            |            |            |            |            |            |            |            |            |
| 40               | 36        | 37        | 38        |           |           |            |            |            |            |            |            |            |            |            |
| 41               | 38        | 39        | 40        |           |           |            |            |            |            |            |            |            |            |            |
| 42               | 40        | 41        | 42        | 43        |           |            |            |            |            |            |            |            |            |            |
| 43               | 42        | 42        | 43        | 44        |           |            |            |            |            |            |            |            |            |            |
| 44               | 44        | 45        | 45        | 46        |           |            |            |            |            |            |            |            |            |            |
| 45               | 46        | 47        | 47        | 48        | 49        |            |            |            |            |            |            |            |            |            |
| 46               | 48        | 48        | 49        | 50        | 51        |            |            |            |            |            |            |            |            |            |
| 47               | ---       | 49        | 50        | 51        | 52        | 53         |            |            |            |            |            |            |            |            |
| 48               | ---       | 51        | 52        | 53        | 54        | 55         | 56         |            |            |            |            |            |            |            |
| 49               | ---       | 53        | 54        | 55        | 56        | 57         | 58         |            |            |            |            |            |            |            |
| 50               | ---       | ---       | 56        | 57        | 58        | 59         | 60         | 61         |            |            |            |            |            |            |
| 51               | ---       | ---       | 59        | 60        | 61        | 62         | 63         | 64         |            |            |            |            |            |            |
| 52               | ---       | ---       | 62        | 63        | 64        | 65         | 66         | 67         |            |            |            |            |            |            |
| 53               | ---       | ---       | ---       | 66        | 67        | 68         | 68         | 69         | 70         |            |            |            |            |            |
| 54               | ---       | ---       | ---       | 68        | 69        | 70         | 71         | 72         | 73         |            |            |            |            |            |
| 55               | ---       | ---       | ---       | ---       | 72        | 73         | 74         | 75         | 76         | 77         |            |            |            |            |
| 56               | ---       | ---       | ---       | ---       | 76        | 77         | 78         | 79         | 80         | 81         |            |            |            |            |
| 57               | ---       | ---       | ---       | ---       | ---       | 81         | 82         | 83         | 84         | 85         | 86         |            |            |            |
| 58               | ---       | ---       | ---       | ---       | ---       | 85         | 86         | 87         | 88         | 89         | 90         | 91         |            |            |
| 59               | ---       | ---       | ---       | ---       | ---       | 89         | 90         | 91         | 93         | 94         | 95         | 96         | 98         |            |
| 60               | ---       | ---       | ---       | ---       | ---       | ---        | 94         | 95         | 97         | 99         | 100        | 102        | 104        | 106        |
| 61               | ---       | ---       | ---       | ---       | ---       | ---        | 99         | 101        | 102        | 104        | 106        | 108        | 109        | 111        |
| 62               | ---       | ---       | ---       | ---       | ---       | ---        | 104        | 106        | 107        | 109        | 111        | 113        | 114        | 115        |
| 63               | ---       | ---       | ---       | ---       | ---       | ---        | 109        | 111        | 112        | 113        | 115        | 117        | 118        | 119        |
| 64               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | 115        | 117        | 118        | 119        | 120        | 121        | 122        |
| 65               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | 117        | 119        | 120        | 122        | 123        | 124        | 125        |
| 66               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | 119        | 121        | 122        | 124        | 126        | 127        | 128        |
| 67               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | 124        | 126        | 127        | 128        | 129        | 130        |
| 68               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | 126        | 128        | 130        | 132        | 133        | 134        |
| 69               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | 129        | 131        | 133        | 135        | 136        | 137        |
| 70               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | ---        | 134        | 136        | 138        | 139        | 140        |
| 71               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | ---        | 138        | 140        | 142        | 143        | 144        |
| 72               | ---       | ---       | ---       | ---       | ---       | ---        | ---        | ---        | ---        | ---        | 145        | 147        | 148        | 149        |

Tables by Dr. Thomas D. Wood, Professor of Physical Education, Teachers College, Columbia University.

#### About what a girl should gain each month

| Age                  | Age                 |
|----------------------|---------------------|
| 5 to 8..... 6 oz.    | 14 to 16..... 8 oz. |
| 8 to 11..... 8 oz.   | 16 to 18..... 4 oz. |
| 11 to 14..... 12 oz. |                     |

Height and weight to be taken in house clothes, without shoes. Weigh on the same date each month, about the same hour of the day. Age, the nearest birthday.

TABLE IV. WEIGHT AND HEIGHT FOR MEN AT DIFFERENT AGES\*

| Height | 19 ys. | 20  | 21-22 | 23-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 |
|--------|--------|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 5 ft.  | 107    | 110 | 114   | 118   | 122   | 126   | 128   | 131   | 133   | 134   | 135   |
| 1 in.  | 112    | 115 | 118   | 121   | 124   | 128   | 130   | 133   | 135   | 136   | 137   |
| 2 in.  | 117    | 120 | 122   | 124   | 126   | 130   | 132   | 135   | 137   | 138   | 139   |
| 3 in.  | 121    | 124 | 126   | 128   | 129   | 133   | 135   | 138   | 140   | 141   | 142   |
| 4 in.  | 124    | 127 | 129   | 131   | 133   | 136   | 138   | 141   | 143   | 144   | 145   |
| 5 in.  | 128    | 130 | 132   | 134   | 137   | 140   | 142   | 145   | 147   | 148   | 149   |
| 6 in.  | 132    | 133 | 136   | 138   | 141   | 144   | 146   | 149   | 151   | 152   | 153   |
| 7 in.  | 136    | 137 | 140   | 142   | 145   | 148   | 150   | 153   | 155   | 156   | 158   |
| 8 in.  | 140    | 141 | 143   | 146   | 149   | 152   | 155   | 158   | 160   | 161   | 163   |
| 9 in.  | 144    | 145 | 147   | 150   | 153   | 156   | 160   | 163   | 165   | 166   | 168   |
| 10 in. | 148    | 149 | 151   | 154   | 157   | 161   | 165   | 168   | 170   | 171   | 173   |
| 11 in. | 153    | 154 | 156   | 159   | 162   | 166   | 170   | 174   | 176   | 177   | 178   |
| 6 ft.  | 158    | 160 | 162   | 165   | 167   | 172   | 176   | 180   | 182   | 183   | 184   |
| 1 in.  | 163    | 165 | 167   | 170   | 173   | 178   | 182   | 186   | 188   | 190   | 191   |
| 2 in.  | 168    | 170 | 173   | 176   | 179   | 184   | 189   | 193   | 195   | 197   | 198   |
| 3 in.  | 173    | 175 | 178   | 181   | 184   | 190   | 195   | 200   | 202   | 204   | 205   |
| 4 in.  | 178    | 180 | 183   | 186   | 189   | 196   | 201   | 206   | 209   | 211   | 212   |
| 5 in.  | 183    | 185 | 188   | 191   | 194   | 201   | 207   | 212   | 215   | 217   | 219   |

In ascertaining height—measure in shoes; stand erect, and press measuring rod down against scalp. Weigh yourself in indoor clothing and shoes. Subtract one inch for height, if measured in shoes.

TABLE V. WEIGHT AND HEIGHT FOR WOMEN AT DIFFERENT AGES\*

| Height       | 19 ys. | 20  | 21-22 | 23-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 |
|--------------|--------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| 4 ft. 10 in. | 98     | 102 | 106   | 110   | 113   | 116   | 119   | 123   | 126   | 129   |
| 11 in.       | 103    | 107 | 109   | 112   | 115   | 118   | 121   | 125   | 128   | 131   |
| 5 ft.        | 109    | 112 | 113   | 115   | 117   | 120   | 123   | 127   | 130   | 133   |
| 1 in.        | 113    | 115 | 116   | 118   | 119   | 122   | 125   | 129   | 132   | 135   |
| 2 in.        | 116    | 118 | 119   | 120   | 121   | 124   | 127   | 132   | 135   | 138   |
| 3 in.        | 120    | 121 | 122   | 123   | 124   | 127   | 130   | 135   | 138   | 141   |
| 4 in.        | 123    | 124 | 125   | 126   | 128   | 131   | 134   | 138   | 141   | 144   |
| 5 in.        | 126    | 127 | 128   | 129   | 131   | 134   | 138   | 142   | 145   | 148   |
| 6 in.        | 129    | 130 | 131   | 133   | 135   | 138   | 142   | 146   | 149   | 152   |
| 7 in.        | 131    | 133 | 135   | 137   | 139   | 142   | 146   | 150   | 153   | 156   |
| 8 in.        | 135    | 137 | 139   | 141   | 143   | 146   | 150   | 154   | 157   | 161   |
| 9 in.        | 138    | 140 | 142   | 145   | 147   | 150   | 154   | 158   | 161   | 165   |
| 10 in.       | 141    | 143 | 145   | 148   | 151   | 154   | 157   | 161   | 164   | 169   |
| 11 in.       | 145    | 147 | 149   | 151   | 154   | 157   | 160   | 164   | 168   | 173   |
| 6 ft.        | 150    | 152 | 154   | 156   | 158   | 161   | 163   | 167   | 171   | 176   |

In ascertaining height—measure in shoes; stand erect, and press measuring rod down against scalp. Weigh yourself in indoor clothing and shoes. If shoes have sensible heels, subtract one inch for height; if heels are "high", subtract two inches.

\*Tables prepared by Thomas D. Wood, M. D., Professor of Physical Education, Columbia University. Reprinted from Laboratory Handbook for Dietetics, by Mary Swartz Rose.

**TABLE I. RELATIVE AMOUNTS OF IRON IN THE EDIBLE PORTION**

| FOOD                 | PER CENT |  |
|----------------------|----------|--|
| Egg yolk             | (.0086)  |  |
| Wheat bran           | (.0078)  |  |
| Molasses             | (.0073)  |  |
| Beans, dried         | (.0070)  |  |
| Wheat, entire        | (.0050)  |  |
| Oysters              | (.0045)  |  |
| Almonds              | (.0039)  |  |
| Oatmeal              | (.0038)  |  |
| Spinach              | (.0036)  |  |
| Bread, Boston brown  | (.0030)  |  |
| Dates                | (.0030)  |  |
| Maple syrup          | (.0030)  |  |
| Prunes, dried        | (.0030)  |  |
| Corn, sweet, dried   | (.0029)  |  |
| Gecoa                | (.0027)  |  |
| Dandelion            | (.0027)  |  |
| Pecan nuts           | (.0026)  |  |
| Currents             | (.0025)  |  |
| Bread, graham        | (.0025)  |  |
| Beef steak, med. fat | (.0022)  |  |
| Walnuts              | (.0021)  |  |
| Halsine              | (.0021)  |  |
| Peanuts              | (.0020)  |  |
| Rice, brown          | (.0020)  |  |
| Barley, pearled      | (.0020)  |  |
| Beans, Lima, fresh   | (.0020)  |  |
| Peas, fresh          | (.0017)  |  |
| Tapioca              | (.0016)  |  |
| Bread, entire wheat  | (.0016)  |  |
| Bread, rye           | (.0016)  |  |
| Apples, dried        | (.0015)  |  |
| Apricots, dried      | (.0014)  |  |
| Cheese               | (.0013)  |  |
| Potatoes             | (.0013)  |  |
| Cabbage              | (.0011)  |  |
| Rhubarb              | (.0010)  |  |

| AMOUNTS REQUIRED TO FURNISH .018 GRAMS OF FOOD-IRON |                             |
|-----------------------------------------------------|-----------------------------|
| FOOD                                                | QUANTITY (TO NEAREST OUNCE) |
| EGG YOLK                                            | NO 7                        |
| BEANS, DRIED                                        | NO 9                        |
| OYSTERS                                             | NO 14                       |
| OATMEAL                                             | 1 1                         |
| SPINACH                                             | 1 2                         |
| CORN, SWEET, DRIED                                  | 1 6                         |
| DANDELION                                           | 1 7                         |
| BREAD, GRAHAM                                       | 1 9                         |
| BEEF STEAK (MED. FAT)                               | 1 13                        |
| WALNUTS                                             | 1 14                        |
| PEANUTS                                             | 2 No                        |
| RICE, BROWN                                         | 2 No                        |
| BARLEY, PEARLED                                     | 2 No                        |
| BEANS, LIMA, FRESH                                  | 2 No                        |
| PEAS, FRESH                                         | 2 5                         |
| APPLES, DRIED                                       | 2 10                        |
| POTATOES, IRISH                                     | 3 1                         |
| RHUBARB                                             | 4 No                        |

Iron is necessary to make red blood. The lack of red blood causes anemia. The daily requirement of iron for an adult has been placed at from .015 to .018 grams. Rely upon the daily food supply for enough of iron. Do not be misled by drugs or mineral waters. See that the diet is well supplied with fruits and leafy vegetables.



**TABLE II. RELATIVE AMOUNTS OF PHOSPHORUS IN THE  
EDIBLE PORTION**

| FOOD                | PER CENT |  |
|---------------------|----------|--|
| Cocoa               | (.709)   |  |
| Cheese              | (.683)   |  |
| Egg yolk            | (.524)   |  |
| Beans, dried        | (.471)   |  |
| Chocolate           | (.455)   |  |
| Peas, dried         | (.400)   |  |
| Peanuts             | (.399)   |  |
| Oatmeal             | (.392)   |  |
| Corn, sweet, dried  | (.276)   |  |
| Walnuts             | (.258)   |  |
| Hazelnuts           | (.254)   |  |
| Pecan nuts          | (.335)   |  |
| Beef, all lean      | (.218)   |  |
| Bread, graham       | (.218)   |  |
| Rice, brown         | (.207)   |  |
| Currents, dried     | (.195)   |  |
| Corn meal           | (.190)   |  |
| Bread, Boston brown | (.185)   |  |
| Barley, pearled     | (.181)   |  |
| Oysters             | (.155)   |  |
| Bread, rye          | (.148)   |  |
| Peaches, dried      | (.146)   |  |
| Macaroni            | (.144)   |  |
| Hominy              | (.144)   |  |
| Antisins            | (.132)   |  |
| Peas, fresh         | (.127)   |  |
| Farina              | (.125)   |  |
| Brussels sprouts    | (.120)   |  |
| Figs, dried         | (.116)   |  |
| Prunes, dried       | (.105)   |  |
| Cabbage greens      | (.099)   |  |
| Rice, white         | (.096)   |  |
| Milk (Cow's), whole | (.093)   |  |
| Bread, white        | (.093)   |  |
| Parsnips            | (.076)   |  |
| Spinach             | (.068)   |  |

| AMOUNTS REQUIRED TO<br>FURNISH 1.44 GRAMS<br>OF FOOD-PHOSPHORUS |                                    |
|-----------------------------------------------------------------|------------------------------------|
| FOOD                                                            | QUANTITY<br>(20 NEAREST<br>OUNCES) |
| CHEESE                                                          | No 7                               |
| EGG YOLK                                                        | No 10                              |
| BEANS, DRIED                                                    | No 11                              |
| PEANUTS                                                         | No 13                              |
| OATMEAL                                                         | No 13                              |
| WALNUTS                                                         | No 14                              |
| BEEF ALL LEAN                                                   | 1 7                                |
| BREAD, GRAHAM                                                   | 1 7                                |
| RICE, BROWN                                                     | 1 9                                |
| CORN MEAL                                                       | 1 11                               |
| BARLEY, PEARLED                                                 | 1 12                               |
| PEACHES, DRIED                                                  | 2 5                                |
| HOMINY                                                          | 2 5                                |
| PEAS, FRESH                                                     | 2 8                                |
| CABBAGE GREENS                                                  | 3 4                                |
| RICE, WHITE                                                     | 3 8                                |
| MILK (COW'S)                                                    |                                    |
| WHOLE                                                           | 3 10                               |
| SPINACH                                                         | 4 11                               |

Phosphorus is essential to all of our body tissues. A person weighing 154 pounds should receive 1.44 grams of phosphorus in each day's food. The dietaries of approximately 40 per cent of our homes are below this standard. Foods which are fairly rich in phosphorus should be adequately represented in our daily menus.

TABLE III. RELATIVE AMOUNTS OF CALCIUM IN THE EDIBLE PORTION

| FOOD                | PER CENT |  |
|---------------------|----------|--|
| Cheese              | (.931)   |  |
| Mustard             | (.492)   |  |
| Turnip tops         | (.347)   |  |
| Hazelnuts           | (.287)   |  |
| Almonds             | (.239)   |  |
| Molasses            | (.211)   |  |
| Lupins, dry         | (.191)   |  |
| Figs, dried         | (.162)   |  |
| Beans, dried        | (.150)   |  |
| Chard               | (.150)   |  |
| Egg yolk            | (.137)   |  |
| Bread, Boston brown | (.129)   |  |
| Cauliflower         | (.123)   |  |
| Olives              | (.122)   |  |
| Milk (Cow's), whole | (.120)   |  |
| Wheat bran          | (.120)   |  |
| Cocoa               | (.112)   |  |
| Cabbage greens      | (.106)   |  |
| Buttermilk          | (.105)   |  |
| Dandelion           | (.105)   |  |
| Endive              | (.104)   |  |
| Chocolate           | (.092)   |  |
| Walnuts             | (.089)   |  |
| Peas, dried         | (.084)   |  |
| Gourmets, dried     | (.082)   |  |
| Galery              | (.078)   |  |
| Okra                | (.071)   |  |
| Peanuts             | (.071)   |  |
| Oatmeal             | (.069)   |  |
| Eggs                | (.067)   |  |
| Spinach             | (.067)   |  |
| Turnips             | (.064)   |  |
| Hazelnuts           | (.064)   |  |
| Gourmets            | (.056)   |  |
| Prunes              | (.054)   |  |
| Bread, graham       | (.050)   |  |

| AMOUNTS REQUIRED TO FURNISH 0.67 GRAMS OF FOOD-CALCIUM |                             |
|--------------------------------------------------------|-----------------------------|
| FOOD                                                   | QUANTITY (TO NEAREST OUNCE) |
| CHEESE                                                 | No 3                        |
| MUSTARD                                                | No 5                        |
| MOLASSES                                               | No 11                       |
| BEANS, DRIED                                           | No 15                       |
| CHARD                                                  | 1 No                        |
| EGG YOLK                                               | 1 2                         |
| CAULIFLOWER                                            | 1 3                         |
| MILK                                                   | 1 4                         |
| CABBAGE GREENS                                         | 1 7                         |
| DANDELION                                              | 1 7                         |
| WALNUTS                                                | 1 11                        |
| PEAS, DRIED                                            | 1 12                        |
| OKRA                                                   | 2 1                         |
| PEANUTS                                                | 2 1                         |
| OATMEAL                                                | 2 3                         |
| SPINACH                                                | 2 3                         |
| CARROTS                                                | 2 11                        |
| BREAD, GRAHAM                                          | 2 15                        |

An adult weighing 154 pounds should receive 0.67 grams of calcium in his daily food supply, and a child from three to thirteen years of age needs twice this quantity each day. The dietaries in probably more than 50 per cent of our American homes fall below the amounts required. Liberal uses of milk and the leafy vegetables will insure plenty of calcium.

## ACKNOWLEDGMENTS

The many sources of information which have been consulted in the preparation of this bulletin would require several extra pages to make reference to all of them. We wish to acknowledge our indebtedness to every one of them, but, in a publication of this kind, it would seem necessary to refer to only a few of the more important publications which have been drawn upon by the authors, in which the reader may find additional interest and he may even desire to purchase one or more of the books for further study.

1. *Nutrition and Growth in Children*, by Emerson. Published (1922) by D. Appleton and Company, New York City. Price, \$2.50.
2. *The Vitamins*, by Sherman and Smith (Monograph Series). Published by the Chemical Catalog Company, New York City (1922). Price, \$4.00.
3. *Feeding the Family*, by Rose (1921 edition), published by the Macmillan Company, New York City. Price, \$2.40.
4. *The Vitamines*, by Funk. Published (1922) by the Williams and Wilkins Company, Philadelphia. Price, \$6.00.
5. *The American Home Diet*, by McCollum and Simmonds. Published (1920) by the Frederick C. Mathews Company, Detroit, Michigan. Price, \$3.50.
6. *The Newer Knowledge of Nutrition*, by McCollum (second edition—entirely rewritten). Published (1922) by the Macmillan Company, New York City. Price, \$3.80.
7. *Vitamins and the Choice of Food*, by Plimmer and Plimmer. Published (1922) by Longmans, Green and Co., New York City. Price, \$2.50.
8. *Vital Factors of Foods*, by Ellis and Macleod. Published (1922) by D. Van Nostrand Co., New York City. Price, \$5.00.
9. *The Vitamine Manual*, by Eddy. Published (1921) by Williams and Wilkins Co., Baltimore. Price, \$2.50.
10. *The Journal of Biological Chemistry*, published by the Waverly Press, Baltimore.

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**UNIVERSITY OF ARKANSAS**

**COLLEGE OF AGRICULTURE**

**Agricultural Experiment Station**

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**I THE STRAWBERRY WEEVIL**

**II A FALSE WIREWORM ON STRAWBERRY**

**W. J. BAERG**

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# THE STRAWBERRY WEEVIL

*Anthonomus signatus* Say

W. J. BAERG

The strawberry weevil is the most important insect attacking strawberries in Arkansas. Injuries caused by the weevil often reach 50-100 per cent of the crop. Such life history studies as have been made in the northeast and elsewhere and the control measures recommended there do not strictly apply to conditions obtaining in the Ozark region.

The subject matter in this bulletin is the record of life history studies made at the Arkansas Agricultural Experiment Station; of a series of tests involving the use of various materials intended for the control of the weevil; and of some observations on other means of preventing weevil injury.

## CONDITIONS IN THE OZARK REGION AS RELATED TO CULTURAL METHODS OF INSECT CONTROL

Control measures for most insect pests have a very intimate relationship with not only the temperature and moisture conditions; but also with the methods of culture of the particular crop concerned. Strawberry growing in many instances in the Ozark region of Northwest Arkansas is carried on under conditions quite different from those obtaining in the northeastern states where the strawberry weevil has been studied. It therefore seems desirable to discuss briefly some of the features of strawberry culture in Northwest Arkansas.

The first step in starting a new strawberry bed usually is to clear off a piece of woodland. The soil on the hills is rather abundantly mixed with fragments of a flinty rock or chert. Many of the beds are so rocky that at first glance no soil seems to be visible among the rocks. Yet the strawberries make good growth and yield fair returns for two or three years, after which the plants begin to deteriorate.

As already indicated in the method of setting out new beds, these beds are almost always surrounded entirely or in part by woodland. This brings with it a liberal assortment of wild blackberries, dewberries, raspberries, and often also red bud and other host plants of the strawberry weevil.

The rocky soil makes clean culture a gigantic task, if not an impossibility, and the frequent changing of the beds is not practiced because of the labor and the expense involved. Burning over the adjoining woodland along with the beds is not favored by the growers because apparently too many plants are killed by this procedure.

The brief discussion of the growing of strawberries is in-



swered "yes" and 24 "no," (one not answering) indicating that in the owners' judgment practically three-fourths of the machines considered were profitable to their owners, while 24 or practically one-fourth were not considered profitable. However, several owners of unprofitable outfits modified their answers in such a way as to indicate that there was a definite reason why their machines did not return a profit, only about 12 being definitely opposed to the use of tractors for power.

**Location:** Fifty-one of the tractors considered were in eastern Arkansas, 9 in the central or northeast portion of the state, 12 in the northwest portion, and 28 in the southern section of the state.

By counties the tractors studied are located as follows: Lonoke 18, Ashley 7, Woodruff 7, Desha 6, Lee 5, Arkansas 4, Independence 4, Phillips 4; 3 tractors in each of the following: Yell, Benton, Bradley, Clark, St. Francis, Drew, Washington and Dallas; 2 tractors in each of the following: Scott, Prairie, Lafayette, Green, White, and Pope; while Crawford, Franklin, Crittenden, Sebastian, Hot Spring, Johnson and Jefferson are represented in this investigation by one tractor each.

**Age of Tractors Studied:** The general average age of the 100 machines was 3.6 years distributed as follows: 16 were 1 year old machines; 9 were two year old machines; 28 were 3 year old machines; 32 were 4 year old machines; 18 were 5 year old machines; 2 were 6 year old machines; and 6 were from 7 to 10 years old.

**Estimated Life:** Each owner was asked how much longer he considered that his tractor would last. This figure added to the number of years already operated furnished an estimate on the life of the tractors. The average figure was 7 years, which corresponds quite closely with all other investigations and indicates an average life of 6 to 8 years.

It will be noted that the average estimated life of the tractors studied was seven years. Therefore, the annual run-down or depreciation is about fifteen per cent each year, based on the cost of the machine. Thus, a tractor costing \$1000 will be charged with approximately \$143.00 per year. As a matter of actual fact, much more than \$143.00 is taken from the re-sale value by the first year's operation because the machine will then have to be offered as second hand; but over a period of years it has been found reasonable to take about fifteen per cent of the cost at the end of each season for depreciation.

**Distance from Town:** The average machine was exactly 5 miles from town, the distance varying from "in town" out to a distance of 30 miles. However, there were only 7 men who lived more than 10 miles from a station. This factor has no bearing on the selection of a machine, but it does have some

effect on the time lost in case of immediate need for repairs.

**Size of Farm:** The number of acres of tillable land ranged from 25 acres in the case of one apple orchard up to 4000 acres in one plantation. The average size of tillable farm was 500 acres. There were 7 farms of 100 acres or less in size, and 28 farms over 500 acres, the remainder being between 100 and 500 acres. Of the 7 farms 100 acres or less, all successfully operated their tractors, 3 being fruit farms and 3 general farms doing custom work, and only 1 doing no outside work. Of the 28 farms over 500 acres, nine or 33 per cent had unprofitable tractors.

**Crops Grown:** Forty-six raised cotton and corn as the principal crops. Twenty-five farmers raised rice almost exclusively. Nine combined rice with other crops, principally hay. There were 9 general farms and 6 fruit and truck farms.

**Operations Used For:** It is difficult to classify the tractor according to various operations because the value of tractor power lies in its adaptability to the various farm jobs. The operations most frequently mentioned as the principal work for the tractor were plowing, discing, cultivating and harvesting. Several gave breaking new ground or sod as the principal job. One used his machine almost altogether for hay, 3 for belt work and 1 for road work.



FIGURE 2.

Nearly all farmers use horses or mules for row cultivation.

All of the owners considered that horses or mules were the better for some purposes specifically mentioning hauling, road work, planting, seeding and cultivating. Thirteen preferred them for practically all farm work. It may be well to emphasize here that the tractor is not expected to displace the horse in all farm work, but only for those operations in which the tractor with its larger power unit can effect a distinct saving in man and horse labor. On many farms it is not possible to displace any men or horses during the entire year, 30 stating that they could not do so. However, all but 12 men who answered the question on this point made a saving in man and horse labor during crop season. On all farms considered, there was an average saving of 2 men and 5.6 horses in the crop season for every farm, and an average saving of 1 man and  $2\frac{3}{4}$  horses the year round. Included in these figures were all those who answered this question whether or not they made a saving.

Fifty-five users reported that the work could be done cheaper with tractors than with horses, while 23 reported that horses were cheaper to maintain. It is to be noted here that practically all those who found the tractor unsuccessful on their farms considered horses to be the cheaper power.

**Reasons for Buying:** Thirty owners gave as the main reason for purchasing a tractor the fact that they could do quicker or better work in seed bed preparation. Nineteen bought tractors to save their men and horses from heavy work. Seventeen bought tractors as a source of cheap power, 10 because they thought it would be a profitable investment. Four purchased tractors for public work or commercial power, and 2 for orchard cultivation alone.

**Size of Tractor:** Seventy-five machines were of the 2-plow size, which shows a wider use than any other. Nineteen were 3-plow machines and 6 were designed for more than 3 plows. Several did not answer this question, but the proportion between two and three-plow machines is about as given above. Most of the owners were satisfied with the size they had purchased. Sixty-two stated that if they were purchasing another tractor they would buy the same size. Fifteen thought larger machines would better serve their purposes and 7 owners with 3-plow tractors or larger wanted smaller outfits. The type of tractor used principally was the 4-wheel machine. Of 7 owners who had "track-layer" types, 5 preferred this sort of a machine while 2 preferred the wheeled outfit. On the other hand, 5 men who had 4-wheel machines wanted the track-layer type. Since the advent of the lighter weight machine several years ago, there is practically no objection on account of injurious packing of the soil. Only 3 men stated that the tractor packed the soil to an extent that it injured the ground, while several stated

that the weight of the machine had a beneficial effect on the soil.

**Acres Plowed per Day:** The average day's work of the two-bottom plow was 5 to 6 acres and of the three-bottom plow 7 to 8 acres per day. A few of the larger machines plowed 9 or 10 acres, and the general average was 7 acres per day.

**Fuel Used:** Twenty-eight owners used gasoline as the tractor fuel, and seventy-two, out of the one hundred studied, used kerosene. The average amount per day for all fuels used was 17 gallons. In general, it is found that from three to five gallons more kerosene per day is used than gasoline for the same size tractor, however, the cost of fuel per day, or per acre depends on the local price of kerosene and gasoline. Kerosene usually costs from 10 to 13 cents per gallon less than gasoline.

On the basis of the amount of fuel used per acre, the kerosene tractors require 2.6 gallons for each acre plowed, while the gasoline tractors require slightly less than 2.2 gallons per acre; or very nearly one-half gallon less gasoline than kerosene was used per acre.



FIGURE 3.

The tractor speeds up seed bed preparation or orchard cultivation.

**Amount of Time Used:** The days per year and the hours per day which the tractor is used has some influence on the life of the machine and also on the success or failure. Some machines were used only 30 or 40 days in the year, while others

were used from 100 to 200 days. The average of all was approximately 83 days per year, and by far the largest number of the machines were kept in the field 10 hours per day. There were only 7 successful tractors that did less than 60 days work per year, and 4 of these were on special crops such as fruit or rice where timeliness is one of the most important factors. There were 2 unsuccessful machines that did more than 150 days work in the year, whereas a considerable number of the successful outfits worked more than 150 days.

**Who Operates the Tractor:** The owner operated his own tractor in 29 cases. His son operated the machine in 8 cases, and an experienced farm hand or mechanic in 9 cases. Fifty machines were operated by common labor or by several different members of a family. As a rule, it is desirable that some one operate the tractor who has a personal interest in it, or who has had some special training for the work.

**Repair Costs:** The average estimated repair cost was \$30.00 per year, ranging from practically no expense to an extreme of \$400.00. Sixty-one operators stated in their estimation the repair cost was reasonably low, while 22 stated that their repairs were very high. Averaging the high costs it was found that 15 men spent an average of \$210.00 each as compared with the general average of \$30.00 per year including all reports. It may be noted here that of the 22 men who considered that their repair costs were high only 9 considered their machines a profitable investment which shows a close relation between the amount of trouble and final success or failure of the machines. There were but 2 successful tractors reporting over \$100.00 repairs in a single year, while only 7 unsuccessful machines reported less than \$100.00, and 7 unsuccessful outfits cost over \$200.00 per year for repairs.

**Operating Costs:** No figures can be given which will show the exact operating cost for any particular tractor. The following figures which are based upon the general average of the tractors studied are given more to show the various factors than to be taken as actual for any special machine.

It will be noted that the cost will vary greatly with the kind of tractor, number of days used, repair costs, ability of operator and similar factors. Many economical operators are able to show a lower cost than that given here, but on the other hand there will be a considerable number who will fail to keep the operating cost down to the average figure.

The items that must be considered in tractor operating costs are: interest, depreciation, fuel, lubricating oil, repairs and operator.

|                                                          |          |
|----------------------------------------------------------|----------|
| If the tractor costs \$1000, interest at 8% will be----- | \$ 80.00 |
| Depreciation at 15%-----                                 | 150.00   |
| Average annual repair bill-----                          | 30.00    |

Total average overhead costs-----\$260.00

The average number of days used was eighty-three. Dividing the overhead cost of \$260.00 by 83 gives \$3.10 as an average daily overhead charge.

Based on daily costs, we then have the following:

|                                      |        |
|--------------------------------------|--------|
| Overhead charges per day-----        | \$3.10 |
| 17 gallons fuel per day @ 15¢-----   | 2.55   |
| 1 gallon lubricating oil @ 90¢-----  | .90    |
| Operator 10 hrs. @ 20¢ per hour----- | 2.00   |

Total cost of operation per day-----\$8.55

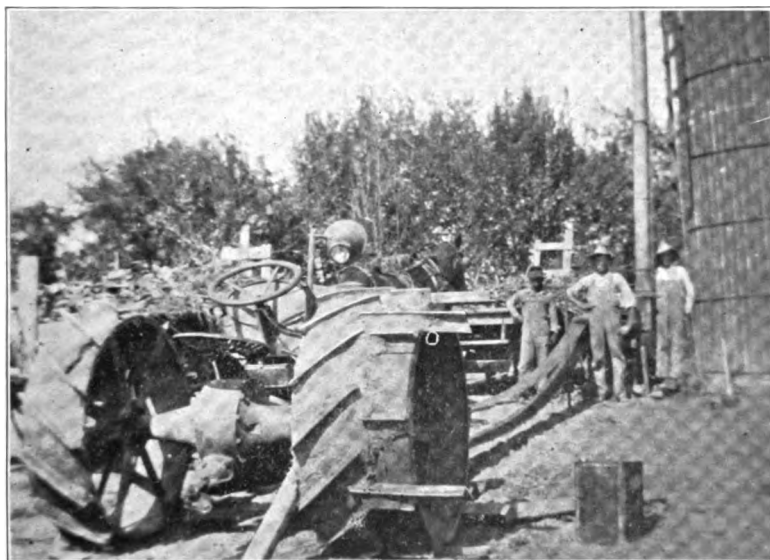


FIGURE 4.

Belt work is an important factor in successful operation.

As the above figures are used as a basis on which to figure the actual cost, it should be noted that the overhead charges include the interest and depreciation on the actual cost of the tractor and average annual repair bills. This overhead is then divided by the number of days used, to get the overhead charge per day of use. To this charge must then be added the fuel and lubricating oil at local prices, and the cost of the man to operate

the tractor. If an owner operates his own machine, he should charge at least 20 cents per hour, since the operation of a tractor requires a higher priced labor than general farm work.

**Tractor Troubles:** The troubles incurred which caused high repair bills were given as follows: Ten were due to ignorance or carelessness of the operators; 10 to rapid wear and tear on the machines; soil conditions were responsible for trouble with 4 machines; 29 had mechanical trouble of one sort or another, and 10 gave miscellaneous causes. No doubt many of the mechanical difficulties encountered were due to carelessness or ignorant operators.

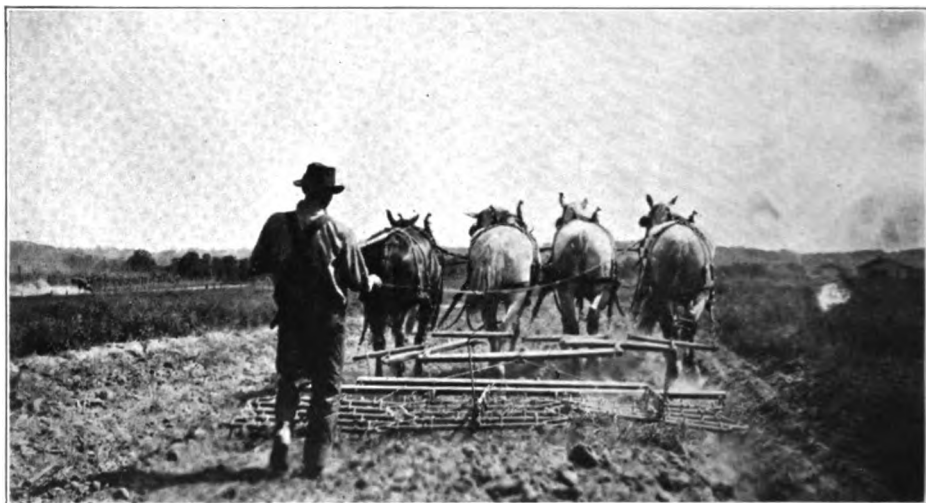


FIGURE 5.

Four horses per man instead of one or two is good business.

**Custom Work:** Thirty-five owners did some outside work, or custom work, principally threshing, breaking land, harvesting rice, grading roads and cultivating orchards. About 60 owners stated that they did not do any outside work. Nine of those who did custom work stated that it did not pay; and 5 of these 9 had unsuccessful tractors. Twenty-nine successful tractors did custom work, and 23 of them made a profit by so doing.

**Why Don't More Farmers Buy Tractors:** This question was asked of the owners, and 20 stated that it was lack of money which prevented most men from purchasing tractors. Fifteen stated that the machines cost too much. Ten stated that more were not purchased because the machines were unprofitable. Fifteen stated that farmers did not realize the value of tractors.

Seven gave inexperienced operators as the reason, and 6 gave miscellaneous answers to this question.

Both the size of farm and the type of farming should have some bearing on the problem of buying a tractor. The orchard men stated that the farm should be from 30 to 60 acres in size before it can profitably support a tractor, while the general farmers and rice farmers consider it necessary to work from 80 to 200 acres of land, and in a few cases the estimate was 400 or 500 acres before a tractor would prove profitable. The average of all opinions was that 116 acres was the least size of farm on which a tractor would prove profitable.

### ANALYSIS OF TRACTOR FAILURES

As an aid in finding an answer to the question of whether or not the farmer should buy a tractor, the following paragraphs will take up the discussion of the 24 machines which were counted as failures by their owners in order that the prospective purchaser may avoid the mistake of others and reduce the chances that his machine might prove unsuccessful.

For the benefit of the prospective customer, the dealer, and the manufacturer, it is essential that the percentage of tractor failures be reduced to a minimum. Unavoidable factors such as the inability of the owner to handle his machine may cause a failure. A large number of the failures, however, are due to preventable causes, and the time to avoid these reasons for failure is before the tractor is purchased. The dealer should not attempt to sell a machine if he cannot make provision for a certain amount of service and furnish essential repairs promptly. Neither should he attempt to sell a tractor to a farmer unless it appears that the farmer has a definite need for additional field or belt power or can increase his farming operations to make a definite saving in men and horses.

**Number of Failures:** Twenty-four machines were reported as unsuccessful and the following study is based on these 24 machines.

**Crops Grown:** Twelve raised cotton, or cotton and corn as the chief crop, several on large plantations where direct supervision of the help was not possible. Six raised general crops and 6 raised rice exclusively.

**Location:** The unsuccessful tractors were distributed throughout the state, no particular locality having any unusual number of unsuccessful machines.

**Size:** Fifteen were of the common 10-20, two-plow size; 3 were smaller and 6 were larger than the 10-20 size. All of those who had small machines stated that if they were purchas-



ing again they would buy a larger outfit. Three of the 6 owners of larger machines stated that if they were purchasing again they would buy a smaller size. Ten of the owners in answer to this question stated that they would buy "none" next time. All 10 of these owners had average size machines.

**Size of Farm:** The size varied from 125 acres of tillable land up to several thousand acres. The size seemed to have little effect on the profit or loss on average sized farms.

**Saving of Men and Horses in Season:** There appeared to be a saving of 1 man and 3 horses with the unprofitable outfits as compared with the general saving of 2 men and 5 or 6 horses taking all farms together. Very little year-around saving was reported by unprofitable outfits.

**Days and Hours Used per Year:** These figures were on the average the same as for all machines. However, as stated above, there were only 2 unsuccessful tractors that did more than 150 days work in a year, whereas many of the successful machines did more than this amount of work. Several of the unprofitable tractors did only 20 to 50 days work in the year.

**Acres Plowed per Day:** This figure was 6 for the unsuccessful outfits as compared with 7 acres per day for all machines. The difference was probably due to necessary stops for making repairs, etc.

**Custom Work:** Eighteen of the 24 unsuccessful outfits did no custom work. Five of the 6 who did outside work said that it did not pay.

**Cost of Repairs:** Thirteen out of 20 reporting on this question mentioned high repair bills. The average cost of the high repair amounts was \$210.00 for each machine as compared with the general average of \$30.00 per year including both high and low.

**Remarks:** Seven stated that a tractor of some other type or size might be profitable on their farm. A few stated that their machines were purchased at the "peak price" and that if the investment were less the machines could be successfully operated. Of the unprofitable machines on the rice farms, all the owners made statements that modified their answers as discussed elsewhere. Only about 12 were definitely opposed to tractor power as a result of their experience.

**Cause of Failure:** The following conclusions may be drawn from this discussion as being factors in the failure of the outfits to prove a successful investment. (1) The high repair costs reflecting on poor operation, carelessness and neglect. (2) Lack of adaptation to the farm and the system of farming. (3) Failure to utilize the tractor for a wider variety of operations,

and especially in doing custom work for neighbors. (4) The crops grown have some influence on the failure. (5) The size of farm is a factor in the case of extremely small or large areas.

### HOW TO AVOID FAILURE WITH A TRACTOR

The above analysis of tractor failures is made principally to point out the way by which the prospective purchaser can make his machine more certain of success. Since tractor power has come to stay on the farm, it is only necessary to avoid mistakes which other men have made in order to increase the chances of profitable ownership. There are certain changes that will have to be made when the tractor is purchased in order to farm economically and get the greatest returns for the money invested. Some of the more important changes may be listed as follows:

1. The number of work animals will be reduced.
2. There will be a saving of man labor.
3. The field work can be done at the most opportune time.
4. The number of acres of the principal crops may be increased.
5. More time will be available for live stock and cash crop enterprises.
6. The tractor may be used for custom work.

In considering these points, it must be kept in mind that the tractor owner should attempt not only to reach the average results as brought out in this discussion, but should strive to reach the ideal figures. The mere fact that some men are making exceedingly good records with their machines in time and labor saved and other factors means that after careful study is given to these points the chances of failure will be reduced.

As has been brought out, the owners of successfully operated tractors made a distinct saving in both hired men and horses in the busy season and some of them made a year-around saving that enabled them to dispose of some of their work animals. The farmer who is considering the purchase of a machine should, therefore, carefully analyze his business and see whether or not he can do his work with less than the number of horses he has now. Since most of the cultivating is done with horses, the farmer who is raising a large amount of row crops may need all of his work stock for cultivating and should he purchase a tractor the work animals would be idle during the time of plowing and seed bed preparation.

The same thought must be given to the reduction in man labor. If a certain number of hands must be kept the year around for work with live stock and on crops where hand labor is required, it may be that there will be no real economy in reducing the man labor on plowing and other tractor jobs.

In favorable seasons, there is plenty of time to get the field work done in the proper order and at the proper time. However, if rains or late frosts or other weather conditions delay seed

bed preparation and planting, it may be that the tractor will enable the farmer to get the crop planted or get it harvested, and thus practically save the whole crop by the use of a larger power unit. This point should be given consideration, and may often times be a factor in the success of the outfit.

If the acreage of the principal crop is limited by the ability of the farmer to prepare and plant the seed or by the time available for harvesting, it may be that the purchase of a tractor will make it possible for him to put in and care for a larger acreage of cash crops. If he can do this, he will secure a larger income for the year's work by the use of the tractor. On the other hand, in cotton farming where the picking is the principal problem the tractor would not help to increase the acreage.

It may be also that the purchase of a tractor outfit will make it possible to get the heavy field work done with less time required and with fewer work stock. This means that if the acreage is not increased, the owner will have more time to devote to other lines of work and could care for more dairy cattle, hogs, berries or fruit than he otherwise could, in which case the tractor would aid him in securing a larger income.

One other very great factor in success or failure is the amount of custom work or outside work a farmer does with his outfit. If his farming business is so arranged that he can spend several days or a few weeks each year away from home threshing, grinding feed, cutting firewood, or doing road work he is increas-

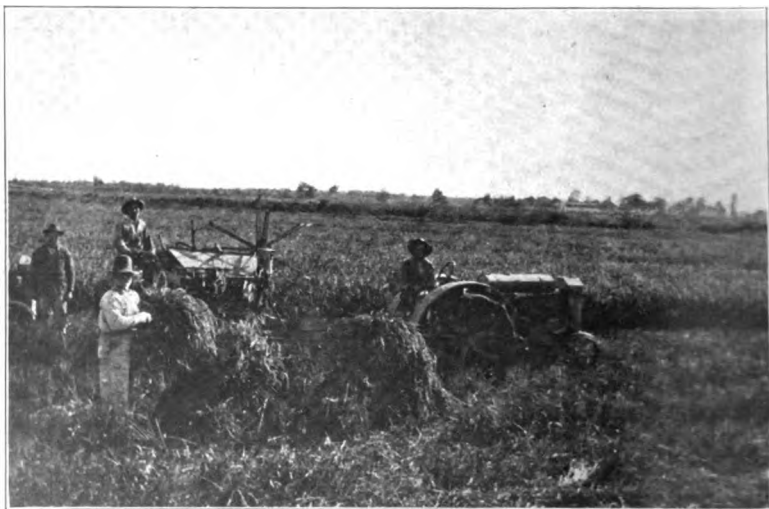


FIGURE 6.

Tractors are widely used in rice farming.

ing the number of days the tractor works, and thereby reducing the overhead cost and at the same time getting good returns for his labor. This additional revenue may make the difference between success or failure with the tractor outfit.

### TRACTORS IN THE RICE DISTRICT

Rice is one crop of the state where tractor power plays a leading part. There are thousands of tractors in the rice counties. From one community comes the following statement: "Ninety-five per cent of the rice farmers in this locality use one or more tractors."

The reasons for the wide spread use of tractors in rice farming may be expressed as follows:

1. Limited seeding time.
2. Part of the work must be done in wet ground.
3. The need to work day and night at the time of the "peak load" of labor.
4. Horses not all needed throughout the year.
5. The heat and dust at harvest time affect horses unfavorably.

In the following list will be found statements made by 24 of the 25 rice farmers who stated that their tractors were a successful investment, giving their views as to why they use tractor power. These remarks in themselves indicate that there is a definite need for power such as is supplied by the tractor in a specialized crop of this sort.

#### Why Bought:

1. Some seasons cannot prepare seed bed and start crop without tractors.
2. Cheaper power and good.
3. Needed it in rice—plowed and seeded 400 acres of oats in three weeks time with one large tractor running day and night.
4. Figured for cheap power for rice.
5. Worked ground in better and shorter time.
6. Concentrated power—some places almost entirely displaced mule power.
7. Less expensive to operate.
8. Better and quicker work—would not be without.
9. It pays in rice business.
10. To get sufficient power.
11. Would not be without it.
12. Bought to save expense.
13. To use for rice culture.
14. For timely work. Ninety-five per cent of rice farmers in my locality have one or more tractors.
15. To reduce expenses—would not be without.
16. More work with less men and horses. Would not do without.
17. For economy.

18. Need more power.
19. For economy.
20. More and better work—especially in rush time.
21. Accomplish more with less labor.
22. More work at less expense—would not do without.
23. Reserve power when most needed.
24. Less expensive power.

In order to get an expression from the dealers who handled tractors in the rice counties, they were asked these two questions:

1. Why do you sell tractors? and (2) Why do farmers buy tractors? Their answers are given here in the dealers' own words.

1. Why do you sell tractors?
  - (a) A little profit—customers do lots of work.
  - (b) We know they are money makers to the farmer that will use them right.
  - (c) Large numbers are used.
  - (d) Farm trade demands tractors.
  - (e) This locality exceptionally good for tractor sales.
  - (f) To enable farmers to produce crop with less expense.
2. Why do farmers buy tractors?
  - (a) Farmers can do lots of work in rice—running them day and night.



FIGURE 7.

Working through heat, dust and long hours in rice harvest.

- (b) They can do so much work in short time with less cost.
- (c) Absolutely essential in this territory.
- (d) Because they can get crop in quicker and in better shape.
- (e) They can do more work.
- (f) Getting work done in limited time; more at less cost.
- (g) To handle larger acreage in less time.

The question of success or failure, as judged by the owner himself, showed that 25 considered the tractor a necessity and an unqualified success. Eight stated that their tractor was not a successful investment. A closer analysis, however, as indicated by their answers to other questions showed that there was a special reason for their failure; or that they would continue to use tractors because of their adaptability to rice farming even though they did not consider them as a profitable investment otherwise. No single one of those who said the tractor was unprofitable appeared to be opposed to tractor power for rice culture as is indicated by their remarks which follow:

1. We use no teams at all except for hauling.
2. It pays in a way—oil is too high.
3. Smaller tractors are more serviceable.
4. Tractor large enough to do belt work would pay.
5. It pays part of the time.
6. O. K. in hot weather. Large farms need one or more.
7. Failure on account of kind and size.
8. If owner operates, and has a suitable farm, it might prove profitable.

From the above discussion of tractors in rice farming, it will be seen that it is not a question of profitable investment, but of the kind, size and type of machine to purchase.

### TRACTORS IN THE FRUIT DISTRICT

Six reports of the 100 answers were from Washington, Benton and Crawford County fruit and truck farms.

While 6 reports are not sufficient in number to justify any recommendations, it is significant that not only were all the tractors considered successful, but in each case the owner commented very favorably on the use of the tractor in orchard work, especially for clean cultivation.

**Remarks:** Following is list of the statements made by each of the six owners of tractors in fruit farms.

1. Could not get work done without them.
2. Would not think of cultivating orchard without them.
3. I would not do without it.
4. We couldn't very well get along without it.
5. Tractors best for all work in orchard.
6. Best for orchard cultivation.

The average acreage of the fruit farms was 111 acres, but the entire acreage was not always in fruit. The average estimate of the size that would profitably support a tractor was 40 acres of orchard. By the use of a tractor, it is possible to disc 20 or more acres per day—which would make it possible to cover a 40-acre orchard in two days with a tandem disc.

### CONCLUSIONS AND RECOMMENDATIONS

On the basis of this questionnaire, tractors as a source of power can be recommended to farmers in the rice district and on fruit farms, provided a careful analysis is made of the needs and a tractor of the proper size and type is purchased. More caution must be advised in recommending machines for cotton or general crops and especially where grown in comparatively small areas. The following recommendation will serve as an aid in the selection of a tractor to fit the farm or in deciding upon an answer to the question of whether or not a tractor is necessary. (1) Realize that each farm is a special problem and the selection will depend upon the kind of crop, acreage, size of field, surface conditions, and the uses to which the tractor may be put. (2) The correct size of machine for the farming operation is one of the most important factors in the selection. (3) Be sure that your dealer or manufacturer can supply efficient service in securing repairs promptly and in supplying expert aid if essential. (4) Usually it is preferable to buy a tractor already represented in the community as this will insure a better repair stock. (5) It will not usually pay to buy a tractor unless a distinct saving can be made in man and horse labor or the farming operations increased in size. (6) Do not expect to operate tractor with careless, ignorant, or inefficient labor, or without proper supervision of the work. (7) The tractor and the company should be reliable. (8) Comfort and safety are important factors and should be given consideration. (9) The mechanical construction of the machine in mind should be studied, especially with reference to accessibility and the ease with which repairs may be put on. (10) On some machines additional equipment is essential, and on all machines certain accessories such as lugs or cleats, extension rims, furrow guides, lights, and air cleaners add to the efficiency of the outfits, and must be considered even though not included in the purchase price. (11) The amount of money invested in a tractor will to some extent be governed by the amount of money available and the size of the farming business. However, the first cost by no means should be the deciding factor. Extra equipment, size, power needs and type all should be considered in the purchase and an effort made to select the machine which is best adapted. Soil conditions and topography may be influencing conditions.

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## THE SOILS OF ARKANSAS

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BULLETIN NO. 187

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FAYETTEVILLE, ARKANSAS

JUNE, 1923

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The Bulletins of this Station are sent free to all residents of the State who request them.



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| C. K. McClelland.....              | Assistant Agronomist           |
| Agnes Nelson.....                  | Assistant Home Economics       |
| L. W. Osborn.....                  | Assistant Agronomist           |
| Carrie Plunkett.....               | Assistant Home Economics       |
| C. W. Rapp.....                    | Assistant Horticulturist       |
| H. R. Rosen.....                   | Associate Plant Pathologist    |
| O. W. Rowland.....                 | Assistant Horticulturist       |
| W. H. Sachs.....                   | Associate in Soils             |
| H. A. Sandhouse.....               | Assistant Animal Husbandman    |
| S. J. Schilling.....               | Associate Veterinarian         |
| S. R. Stout.....                   | Assistant Poultry Husbandman   |
| Barnett Sure.....                  | Associate Agricultural Chemist |
| J. O. Ware.....                    | Assistant Agronomist           |

Address all communications to the director. Notify director of changes in address. Bulletins free upon application.

BRADFORD KNAPP, Director.

## THE SOILS OF ARKANSAS

MARTIN NELSON, WARD H. SACHS, R. H. AUSTIN.

The work on which this report is based was begun a number of years ago. The first draft of the soil map accompanying the report was prepared in 1917 by De F. Hungerford, who was then a member of the Department of Agronomy, and by whom a large number of the soil samples, whose analyses are reported, were collected. In the preparation of the map accompanying this report the field work was supplemented by making use of the county soil maps prepared by the Bureau of Soils, of the United States Department of Agriculture; of the Reconnaissance Survey of the Ozark Region, by C. F. Marbut, of the Bureau of Soils; and of the Geological Reports of the United States, and Arkansas Geological Surveys.

Notwithstanding the constant demand for information contained in this report, publication had to be deferred for several years owing to lack of funds. In the meantime, attention has been devoted to a verification of the soil areas, to the analytical work necessary to determine the character of the many soil types, and to the preparation of a report of practical value to farmers, business men, and others interested in Arkansas land.

The soil survey represented by this report has been completed and is being published under the legislative act of 1921, providing for soil surveys in Arkansas and the publishing of reports of same.

It is not presumed that this report represents the "last word". That stage in the development of Arkansas' most important resource will not be realized until a detailed soil survey will have been made of every part of every county in the state. That much needed work is now in progress, in cooperation between the Arkansas Agricultural Experiment Station and the Bureau of Soils of the United States Department of Agriculture.

Arkansas has a very wide range of soil types and conditions that require close study and careful management. No state has more soil problems, nor is the population of any state more directly dependent upon agricultural production than are the people of Arkansas. Therefore, it is fundamental to the general welfare of her people that the most reliable and the most helpful information possible, as a guide to better management and a more efficient use of her soils, be made available.

### PHYSIOGRAPHY

Draw a line from a point 10 or 12 miles west of Corning, in the northeast part of Arkansas, southwestward, roughly paralleling the main line of the Missouri Pacific Railroad through Newark, Bald Knob, Little Rock, Benton, and Arkadelphia, then

rather sharply westward through DeQueen, to the west border line, and the state has been divided into what may be termed the hill section to the north and west, and the lower lands to the east and south.

Physiographically, these two large sections may be divided again by the Arkansas River, thus giving in the hill portions of the state the Boston region to the north, the Ouachita region to the south, and in the lower land section of the state the terrace and bottom land region of the north, and the sandy hill and bottom land region of the south. Minor divisions in all these regions could be made, notably the Grand Prairie and Crowley Ridge areas in the northern lower land section.

### ALTITUDE

Magazine Mountain, in Logan County, with an elevation of 2823 feet above sea level, is the highest elevation in the state. Magazine Mountain is an outlier of the Ouachita Mountain group, which includes several other peaks of considerable height. Blue Mountain and Buck Knob, of Scott County, with elevations of 2800 feet and 2350 feet respectively, Rich Mountain and Round Mountain of Polk County, with elevations of 2750 and 2300 feet, and Sugar Loaf Mountain of Sebastian County, which rises to an elevation of 2100 feet, are among the important peaks of the Ouachitas.

In the Ozark region to the north of the Arkansas River several peaks in the Boston group exceed an elevation of 2000 feet. Boat Mountain, Boone County, 2200 feet, Lost Mountain, Searcy County, 2200 feet, Walker Mountain, Pope County, 2150 feet, and Sugar Loaf Mountain, of Washington County, 2090 feet, are among the highest points of this region.

The lowest elevation occurs in the southeastern part of the state, where elevations around 100 feet are found. Low water of the Mississippi River at Arkansas City, in Desha County, is recorded as 97 feet. Other low elevations in this region are Cypress and Wilmot, Ashley County, 111 feet and 116 feet respectively, Halley and Trippe, Desha County, 137 feet and 142 feet respectively.

### TOPOGRAPHIC RELIEF

The most rugged topography of the state is found in the Ouachita Mountain region. Logan County, while not so broken as a whole as some other counties, has the widest variation in elevation. Between Magazine Mountain, with an elevation of 2823 feet, and Delaware, 400 feet, near the Arkansas River, there is a variation of over 2400 feet. Corley, with an elevation of 1425 feet in the same township with Magazine Mountain, lies at about 1400 feet lower elevation, and the town of Magazine located

only a few miles distant, with an elevation of only 460 feet, lies almost 2400 feet below the summit of Mount Magazine.

Portions of Scott, Polk, Yell, Montgomery, Perry, and Garland Counties are decidedly broken in character. There is also much broken land in the southern part of Washington, Madison, Newton, and Searcy Counties, and in the northern portion of Crawford, Franklin, Johnson, Pope, and Van Buren Counties. A large part of this more rugged area is retained as a national forest reserve.

The region of least relief is to be found in the eastern part of the state, represented by counties such as Chicot, Desha, and Monroe, where the variation in elevation may not exceed 50 to 75 feet.

### DRAINAGE

Drainage is excessive over much of the hill section. The run-off is rapid and much soil washing takes place. During heavy rains, which occur not infrequently, swiftly flowing water quickly fills the stream courses that remain dry during a large portion of the time, only to subside as quickly as it appeared. Most of the streams, the smaller ones at least, have rapid fall, and occasionally, due to an extremely heavy rain, valuable creek bottom lands have been covered with gravel large enough to seriously interfere with cultivation.

Even the largest streams in the hill section, the Arkansas River being a notable exception, have rapid fall almost, if not quite, to the point where they reach the Coastal Plain or old terrace formations to the south and east.

As an example the elevation at Board Camp, in Polk County, near the head of the Ouachita Valley, is 986 feet above sea level; at Buckville, Montgomery County, 545 feet; at Cove Creek, Hot Springs County, 274 feet; at Arkadelphia, Clark County, 196 feet, while the elevation where the river leaves the state is something less than 100 feet. It is roughly the same distance from Board Camp to Arkadelphia as from Arkadelphia to the point where the river leaves the state, thus in the upper one-half of this stream's course through Arkansas the fall is almost 800 feet, and in the lower one-half only about 100 feet.

In the Arkansas River Valley the fall is more gradual throughout its course within the state, the elevation at Fort Smith being about 420 feet, at Little Rock 260 feet, and at the point where the Arkansas joins the Mississippi about 150 feet, making the fall of the upper portion about 160 feet, and of the lower portion about 110 feet.

Throughout the lower-lying lands in the east and southern portion of the state, where there is little relief, the streams are sluggish. This makes it rather difficult for the streams to clean their channels and increases overflow.

The sandy hill section to the south of the Arkansas River is, on the whole, much better drained than the old terrace formations to the north. The divides between the streams attain sufficient elevation to have good drainage, sometimes excessive, but as the bottom lands are approached the uplands flatten out, and frequently the change from upland to bottom land is very gradual. Some of these divides are prominent features in the areas, as for instance the divide between the Ouachita and Saline River Valleys, upon which is found the Malvern-Princeton Road, and the Monticello Ridge dividing the Saline River watershed from the lowlands to the east. The bottom lands are relatively wide, flat, and poorly drained.

The lower lands north of the Arkansas River are naturally inclined to be poorly drained. Crowley's Ridge and its immediately adjacent lands, however, are fairly well drained. Serious erosion may take place on the Ridge itself. Natural drainage is deficient in the prairie section, but the farmers in this portion of the state have taken advantage of the natural conditions through the growing of rice.

On the whole the bottom lands are not naturally well drained, although throughout the bottom land area there are rather low-lying ridges in a general way paralleling each other, running north and south, which have much better drainage than the intervening lands, these ridges being fairly well drained even under natural conditions. As a general rule these ridges are somewhat sandy in nature and this also adds in their natural drainage.

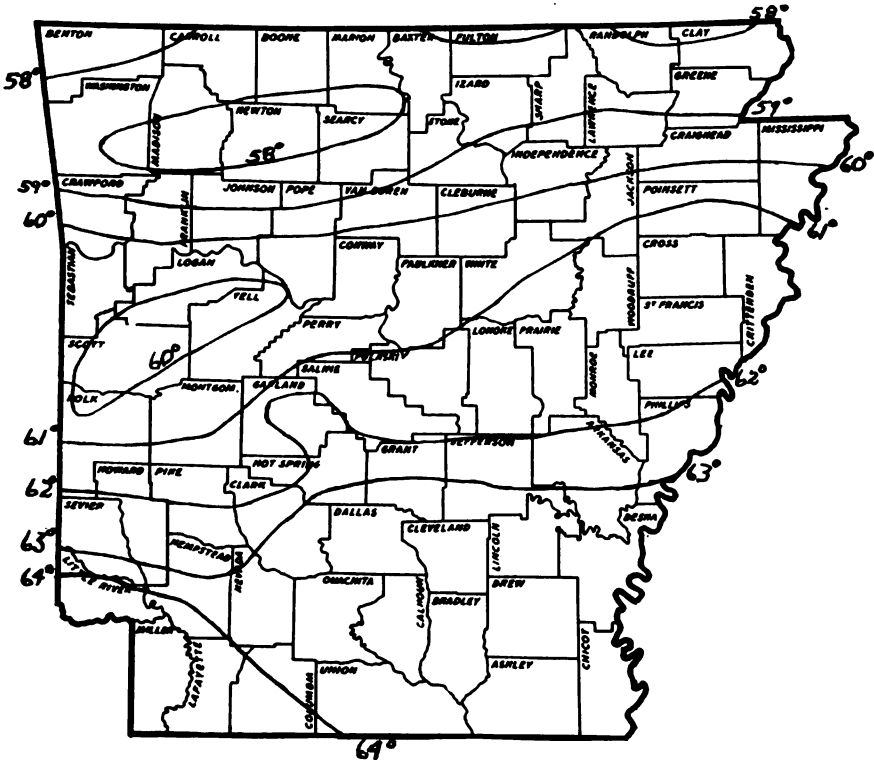
## CLIMATE

The climate of Arkansas is characterized by mild winters and long, warm summers. During the winters rather short periods of cold weather are followed by longer periods of only moderately cold weather. The approach of these "cold snaps" is frequently rather sudden, this being especially true in the northwest section of the state. The winters are mild enough so that plowing can usually be carried on during some part or all of every month in the year.

The mean annual temperature is 58 degrees in Northern Arkansas and 64 degrees in the southern portion of the state. The mean temperature for January at Fayetteville is 37.3, at Malvern 43.1, and at Portland 47.4, while the mean temperature for July is 77.7, 81, and 81.5 degrees respectively.

The average date of the last killing frost in the spring at Fayetteville is April 8, at Malvern April 3, and at Lake Village March 15, while the average date of the first killing frost in the fall at Fayetteville is October 19, Malvern October 31, and Lake Village November 8, giving 193 frost-free days at Fayetteville, 211 at Malvern, and 237 at Lake Village.

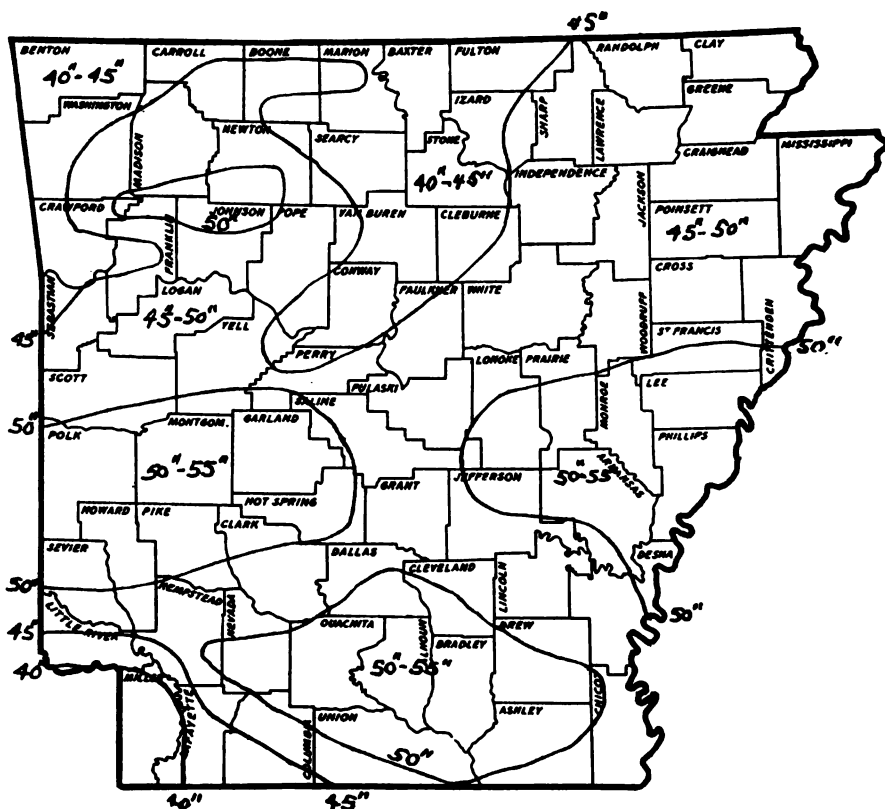
The heaviest annual rainfall occurs in the vicinity of Helena, where the average annual precipitation is 53 inches. The region of least rainfall is in southwest Arkansas in the vicinity of Texarkana. There is ample rainfall in all sections of the state for the production of crops if it were well distributed throughout the year. The seasonal distribution of rainfall is of great importance, and in the following charts taken from the summary of Climatological Data, Sections 47 and 48, published by the United States Weather Bureau, the average monthly rainfall is shown.



Mean annual temperature. From U. S. Weather Bureau data.

Over much of the state heavy rainfall occurs during the winter and spring months, with a falling off in the amount of precipitation during the summer and fall. March, followed by May, are the months of greatest, and October the month of least precipitation. There is considerable variation in the amount of rainfall during the critical months June, July, and August. Thus Dodd City, with an annual precipitation of only 45.9 inches, has an average rainfall during these three months of 13.6 inches,





Normal annual precipitation. From U. S. Weather Bureau data.

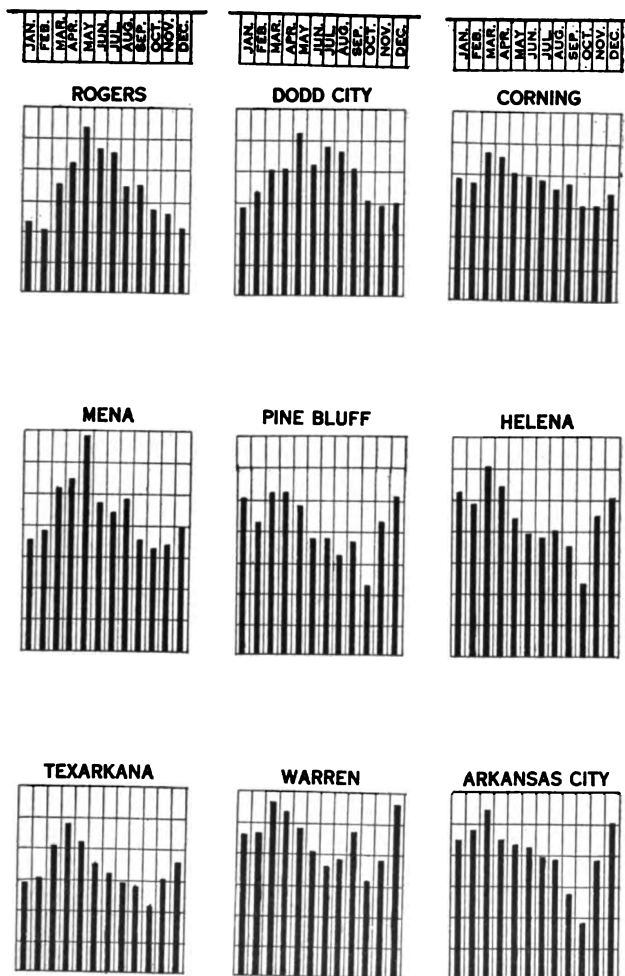
while Pine Bluff, with an annual rainfall of 50.8 inches, has a precipitation of only 10.9 inches during these critical months.

The rainfall of the summer months is frequently rather erratic. It usually accompanies thunder storms, which not infrequently result in very heavy downpours.

The average annual snowfall is 16.9 inches at Bentonville, in Northwest Arkansas, and 1.8 at Arkansas City, in the southeastern portion of the state. Snow falling in Northwest Arkansas may remain on the ground for sometime, though it rarely remains long. In the southeast portion the snow soon disappears.

### NATIVE VEGETATION

Practically the whole of the State of Arkansas was forested at the time development began. There were some prairie areas,



Monthly distribution of rainfall. From U. S. Weather Bureau data.

but these were of relatively small extent when compared to the total area of the state.

The largest area of prairie land is found in East Central Arkansas, in Prairie, Lonoke, and Arkansas Counties. The largest continuous body of prairie land is located in Arkansas and Prairie County, and is called Grand Prairie. Areas of prairie are found north of this section on the west side of Crowley's Ridge, while there is a sandy prairie of note in Poinsett County on the east side of the ridge. There are also

areas of prairie land in Ashley and Drew Counties, of somewhat similar character to the soils of Grand Prairie.

In the southwestern portion of the state in the Black Land section, there are also found small areas of prairie land. Small areas of prairie are even found in the hill section of the state. In Northwestern Arkansas small areas of prairie are found, such as Marshall, Huzza, Osage, and Beatty Prairies.

North of the crest of the Boston Mountains the forests are mainly hardwood. On the rougher, stonier land the trees are short and scrubby, the most commonly occurring trees being black and post oak, black-jack, winged elm, and hickory. Occasionally some short leaf pine is found mixed with the hardwood, and in some local areas almost pure stands of pine are found. Cedar is found on some of the drier bluffs. The foothills and more level areas where the soil is richer support a more valuable growth of white and red oak, hickory, walnut, and linden.

South of the Boston Mountain crest more pine is found in the mixture on the hills, while in the flatter lands sweet and black gum, red and willow oak, elm and hackberry are commonly found. The amount of pine on the south slopes of the Ouachita Mountains is as a general rule much greater than it is on the Boston Mountains, and the percentage increases as the southern limit of the hill section is approached. There is much pine in the southern foothills of the Ouachitas.

In the sandy hill section the better drained lands are occupied by short leaf pine, and there are many large areas where practically pure stands of pine are found. The flatter, poorer drained lands are covered with a growth of hardwood such as sweet and black gum, Spanish, willow, and water oak, and loblolly pine. Cypress and Tupelo gum are found in the swamps.

The Delta, or eastern bottom land section, supports a heavy growth of timber. Probably the largest variety of trees to be found in any region of the state is found here. On the better drained, low ridges white oak, sweet gum, ash, hickory, maple, box elder, slippery elm, and honey locust are found, with sycamores coming in near the stream channels. On the poorer drained lands between these low ridges the trees commonly found are black gum, willow, water and overcup oak, white elm, ash, cottonwood, and willow. Cypress and Tupelo gum are found in the sloughs where water stands during the greater portion of the year.

## GEOLOGY—HISTORICAL

Throughout practically the whole of the hill section the indurated sedimentary rocks lie relatively near the surface, covered only with a mantle of residual disintegrated material. The deposits from which these rocks were formed were laid down in a horizontal position on the floor of an ancient sea. In their

natural position the older rocks would be the rocks occurring at the lowest level. Later warping of the beds caused an elevation of the rocks in the northern portion of the state, as a result of the Ozark uplift, and in the west central portion of the state in the region of the Ouachita Mountains.

The center of the Ozark uplift was in the region of the St. Francois Mountains in Southeast Missouri, where the greatest elevation occurred. While the movement of the earth crust throughout the area was considerably greater in some localities than in others, in general the movement was less as the distance from the center was increased. This resulted in a tilting of the rocks at a greater angle in the northern section than in the southern section of the Ozark region in Arkansas. Except in localities of pronounced local movement, the beds vary only slightly from the horizontal, with only a slight dip to the south.

The Ouachita Mountain region was the scene of more intense movement than the Boston region to the north. Here decided folding of the rock occurred until in some places the rocks now stand in a position perpendicular to that in which they were laid down.

Between these two centers of uplift there is an area where little crustal movement occurred.

Even after the hill section of the state emerged from the sea on whose floor the material forming the present day rocks was laid down, the portion of the state lying southeast of the main line of the Missouri Pacific still remained under water. Erosion of the land areas was constantly going on, the water flowing from the land surface carrying material to the sea and adding it to the steadily accumulating mass.

The sea that covered this part of the state during Cretaceous times, and whose shore line has been indicated to roughly parallel the main line of the Missouri Pacific, covered a large portion of the Gulf States. Its shore line may be indicated by a line passing northeast through southeast Missouri, eastward touching Southern Illinois, then swinging almost directly south through Kentucky, west Tennessee, passing through Corinth, Mississippi, and continuing through Tuscaloosa and Montgomery, Alabama, and Macon, Georgia, and then northward along the fall line of the rivers of the Atlantic Coast. To the southwest this sea covered eastern and southern Arkansas, all of Louisiana, the southeastern portion of Oklahoma, and a large portion of East Texas.

In this Cretaceous sea considerable limestone was deposited. Where this limestone, or chalk, has furnished the material from which the soils of to-day are formed, dark colored rather heavy clay soils are formed. The black prairie lands of Central Alabama, Northeast Mississippi, and Eastern Texas are thus closely

related to the black lands of Clark, Hempstead, and Little River Counties, Arkansas.

Other materials were similarly deposited on the Cretaceous material on the bottom of later seas until finally the whole area was raised above sea level and the state became land. These later beds have never been formed into hard rock as have the older deposited materials.

Widespread erosion has decidedly changed the surface of the area, since the land was raised above sea level. Thus, it is thought that the whole area extending from Crowley's Ridge west to the hill lands once had an elevation equal at least to the height of Crowley's Ridge. A long period of washing resulted in the wearing away of this section to a considerable depth. In rather recent times, geologically, this region has again been filled to some extent.

### CHARACTER OF ROCKS

Since by far the larger portion of the soils of Arkansas are of residual origin, that is, formed from the break-down of rocks in place, the nature of the original rock is important.

In the northern Ozarks the prevailing rocks are sandstone, limestone, chert, and shale, with the sandstone occupying the larger surface areas. Sandstone usually caps the more important hills. In the northeastern part of the hill section where some of the oldest rocks in the state outcrop, there are rather thick beds of limestone, and the weathering of some of these has given rise to rather fertile soils. In the northwestern portion of the hill section limestone beds are also found, but these limestones are usually thinner than those to the east. These limestones usually carry large amounts of chert or flint, while those to the east are relatively chert free. Magnesium limestones, or dolomite, are found in the northern and northeast sections.

Sandstone and shale are the common rocks in the Ouachita Mountain region, although there are thin bedded limestones in the central part of the area. Due to the folding of the rocks these limestones do not affect the soils over wide areas.

Along the eastern border of this area, both in the area and immediately east of it in the lower lying lands, there are several outcrops of igneous rock, locally called "granite". Such areas are of limited extent and of little importance from an agricultural standpoint.

Outside of these two regions that represent the hill section of the state, the material on the surface has never been consolidated into hard rock, with the result that we have gravel, sand, clay, and all variations between, in much the same condition in which they were laid down. Small areas of chalk and of chalky material are found in the southwestern portion of the state, and locally beds of gypsum are found.

## SOIL PROVINCES

The character of a soil is determined by the material from which it is formed and the agencies which act upon this material. As a shale breaks down it will tend to form a clayey soil. A sandstone will form a sandy soil. Soils formed from shale will be of different character where one is formed under arid conditions and the other is formed under humid conditions.

The United States has been divided into soil provinces, the soil in a province having been formed from similar rock and under similar conditions. Five of these provinces are found in Arkansas; namely, Limestone Valleys and Uplands in North Arkansas, Appalachian Mountain and Plateau making up the remainder of the hill section; Coastal Plain, of South Arkansas, Glacial and Loessial, which includes Crowley's Ridge, and the River Flood Plains.

## SOIL CLASSIFICATION

In these provinces subdivisions are made. Following the classification of the United States Bureau of Soils, soils which owe their origin to the same sort of material, formed under similar conditions and having similar characteristics, such as color of surface and subsoil, structure of subsoil, etc., are classed in the same series. These series have usually been named after the locality where the soil was first identified, or where typically developed. Thus, in the Coastal Plain province we have the Orangeburg, the Norfolk, and the Ruston series.

Within a series we find soils of different texture; that is, sand, sandy loam, silt loam, and clay. The coupling of a series with one of these class names gives the name of a type, as the Orangeburg Sandy Loam. The soil type is the unit of soil classification, so all soil belonging to a particular type is similar in all respects, chemical, as well as physical.

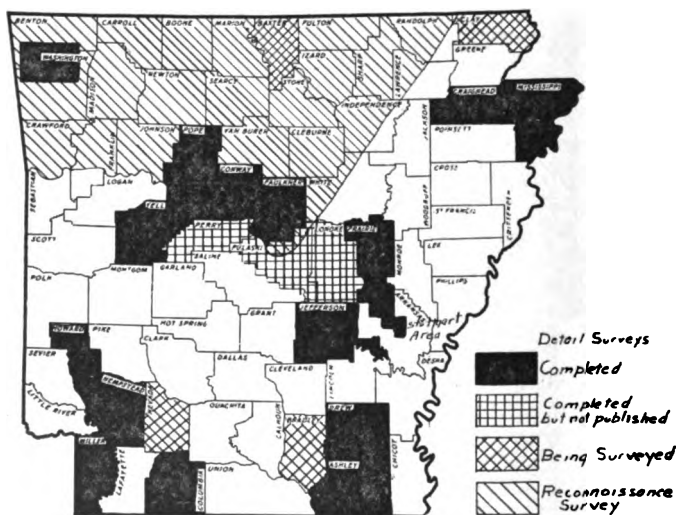
In making a general soil survey of the state it is impracticable to make the unit of classification the soil type, for a map prepared on this basis would require more detail than can be shown on a small map. On the general soil survey map accompanying this report, soils formed under similar conditions, and from rather comparable materials are grouped together. Later in this report a description of the principal soil types occurring within these subdivisions will be taken up.

## MAKING USE OF THE REPORT

In the use of this report a prospective purchaser of a farm in Arkansas can not tell by looking on the map just what sort of a soil is to be found on a particular farm, but he can get an idea of the general soil conditions in the different sections of the

state. He can also, by going on to the land and studying the soil found and reading the descriptive material in the report, get some idea of the conditions even on a particular farm. The farmer by studying the soils on his farm and comparing his findings with the type description, can gain information regarding improvement of his soil.

In making use of this report it is suggested that one interested in a particular farm turn to the map and find the soil area in which the farm is located. Finding the number of the area on the map (for example No. 15), next turn to the "Classification of Arkansas Soils", page (20). Here under this soil area is found six commonly occurring soil types. Now turn to the "Description of Soil Types" and compare the descriptions of these particular soil types with the character of the soil in question. For example, if the soil on a farm is a gray soil with a compact red subsoil it is a Sesquehanna soil, if gray surface with gray compact subsoil it belongs to the Caddo series, while if it is the dark colored prairie soil it is a Houston soil.



Map shows detailed soil surveys completed and reports published, soil surveys completed but reports not published, soil surveys under progress and area covered by reconnaissance survey.

However, in order to gain most benefit from soil survey work, it is necessary to make detailed surveys. In the preparation of the detailed map which is taken up county by county, variations in the soil within a forty-acre field are recognized and shown on the map. Such detailed mapping is being carried on

at the present time in cooperation with the United States Bureau of Soils.

### PHYSICAL PROPERTIES

There is no more heterogeneous or mixed material than is the soil. It is the result of repeated mixing and sorting of loose material on the earth's surface by different physical agencies, such as wind, water, and ice. Material which may have been a soil at one time may become hardened into a rock, to again become soil as this rock is later broken down. Thus the shale, or fire clay, which may be underlying a bed of coal, represents the old soil which supported the growth of vegetation which later formed the coal.

In spite of the fact that soil is a very much mixed material, close examination makes possible the identification of many definite properties. A few of the more important properties will be taken up.

By texture of a soil is meant the relative abundance of different sizes of mineral particles in a soil. The "feel" of the soil between the fingers is dependent largely upon the texture of the soil. There are four general sizes of particles recognized in making up of soil; that is clay, silt, sand, and gravel. Stones and rocks are still larger fragments frequently found in soil.

The material classed as clay includes the smaller particles found in soil. These individual particles can not be seen without the aid of a microscope, as they are all less than one-five-thousandth of an inch in diameter. Being made up of very small particles, true clay possesses peculiar properties which the larger particles in the soil do not have, at least not in so marked a degree. True clay is very tenacious, that is, sticks together when wet. It is this property of the clay contained in large quantities in gumbo or heavy, waxy soil, which makes plowing difficult and produces the snapping or cracking as a vehicle is driven over a muddy road in such a soil. A clay soil is called heavy not because of its weight, but because it produces a heavy draft when being moved, and this draft is due to tenacity. Clay, when moist, can be molded into shape and will retain that shape after drying. This property is called plasticity. Advantage of this property is taken in making pottery and ordinary farm tile.

Clay has the property of shrinking when dry and expanding when wet. This shrinkage, if controlled, is beneficial, while in some soils containing large amounts of clay, shrinkage may take place to such an extent that cracks develop in the surface of the soil into which the foot may be thrust. Such extreme shrinkage is detrimental. These properties of clay are so marked that only a small amount of clay in a soil has a very noticeable effect of the character of the soil.



Silt, which is the next larger sized particle recognized in the soil, is coarser than one-five-thousandth of an inch, and smaller than one-five-hundredth of an inch in diameter. Silt has some tenacity and some shrinkage, but these properties are nowhere as marked as in the case of the clay. Silt is intermediate in its nature between clay and sand.

Sand is composed of particles ranging from one-five-hundredth of an inch to one-twenty-fifth of an inch in diameter. Different grades of sand are recognized, such as coarse, medium, fine, and very fine sand, all of these sands ranging within the above limit. Sand has almost no tenacity. A child playing in the sand pile finds that sand has some tenacity when moist, but this tenacity is soon lost when the sand dries out and the grains fall apart. Sand has no plasticity and does not possess shrinkage to any extent.

Structure in soil refers to the arrangement of the particles composing the soil. That is, the particles may be loose or compact, may be separated into individual particles, or placed together in groups or crumbs. There can be less change in the structure of sand than in silt, and less change in silt than in clay. In fact, a sand can only be compact or loose.

Clay particles have the property of clumping together into small crumbs instead of remaining as individual particles as does the sand. This is due largely to very finely divided glue-like clay particles called colloidal material. Freezing and thawing, alternate wetting and drying, aid in the formation of these small granules or crumbs. The heavy buckshot lands possess this granulating property to a high degree. It is possible to break down this granular structure by working the clay when wet. The potter carries on this puddling process by grinding and working the clay when wet so the granular structure is completely broken down and the clay is in a puddled condition. When a clay soil is puddled the fine particles can settle closely together, and a soil in this condition permits very slow movement of air or water through the spaces between the soil particles.

The structure and texture of a soil determine to a large extent the amount of pore space, or spaces between the particles in the soil. The water available for plant use is held as capillary water in these spaces, in much the same manner as oil moves up a lamp wick, so that the amount of water which a soil can take up and hold as a result of a rain depends largely upon the texture and structure of the soil. A heavy plastic clay in a puddled condition will not be able to hold as much available moisture which it can supply a crop as a clay with a good granular structure.

## CHEMICAL COMPOSITION

By making a chemical analysis of a soil it is possible to determine the total amount of plant food present. A total analysis then is an invoice of the soil's resources.

When an individual attempts to sum up his financial resources, he finds that some of his assets may be tied up in land, some represented by stocks and bonds, some by notes, and some in cash. Cash is always readily available. A good note is usually more easily liquidated than stocks or real estate. Under certain conditions it is rather difficult to get the true purchasing power out of a good note. In the soil the plant food resources are present in different forms. Some of the plant food is readily available, other portions are slowly available, while other portions are very difficultly used by the plant.

A total analysis then, simply gives the total plant resources of the soil and tells nothing of the availability of these different plant foods. A total analysis can not give very much idea in regard to the yield of a particular plot any certain year, although as a general rule soils rich in total plant food will usually have an abundance of available material so that we naturally expect larger crops from soils containing considerable amounts of plant food. Chemists have tried, and have succeeded to a certain extent, in measuring the amounts of available plant food in the soil, yet at the present time it is not practical to attempt to use these methods on a large scale.

While a total analysis has its limitations, still its value from a standpoint of establishing a permanent agriculture can not be questioned. If a total analysis shows an element of plant food to be decidedly low, it would be well to count on making applications of this element from time to time. If, however, large quantities of the plant food are shown to be present, then instead of buying more of this element the plan should be the adoption of means to make the supply of this element in the soil more readily available.

## NITROGEN AND PHOSPHORUS CONTENT

The analyses reported later show the supply of total nitrogen and phosphorus in the more commonly occurring soil types. These results are based on determinations made on over one-thousand samples. Most of the samples on which these determinations were made were collected in two portions; the surface soil, consisting of the surface seven inches of soil, and the subsoil, extending from seven inches down to thirty-six inches, although some of the subsoils were collected only down to twenty-one inches below the surface of the ground.

The surface seven inches of an average soil weighs approx-

imately 2,000,000 pounds, and the \*nitrogen and phosphorus are expressed in pounds per acre on this basis. Actually, the subsoil extending from seven to twenty-one inches would weigh approximately 4,000,000 pounds, and the subsoil extending from seven to thirty-six inches would weigh approximately 8,000,000 pounds. However, it is felt that it would be well to express plant food contents on the same basis as in the surface soil and possibly avoid some confusion. The farmer is interested mainly in the plant food content of the upper portion of the soil, the surface soil, and the first few inches of the subsoil, as it is from this portion of the soil that the plants draw most of their food. The plant food content of the subsoil is of nowhere near the same importance as the plant food content of the surface soil. No matter how rich the subsoil may be in total plant food, if it is covered by a poor, rundown surface soil, the seeds which sprout in the surface soil will wither and dry up before the roots can penetrate to the rich subsoil below. We are interested in the subsoil mainly from the standpoint of its physical condition and its ability to hold moisture in available form. This statement is not intended to minimize the importance of the character of the subsoil, for it is the opinion of the authors that far too little attention is paid to the subsoil.

The amounts of nitrogen and of phosphorus which should be found in a fertile soil have been suggested by different soil investigators. The figures 5,000 pounds of total nitrogen and 2,000 pounds of total phosphorus in 2,000,000 pounds of surface soil are sometimes used. By comparing the analyses of Arkansas soils reported, with the figures as a standard, it will be seen that a large portion of the soils of Arkansas fall far short. In fact, in the states where the standards are suggested, few of the soils found will contain the 2000 pounds of phosphorus and the suggested nitrogen content is much higher than the average found.

Under the conditions which prevail in the South a small total supply of plant food, and especially of nitrogen, can be expected to give a larger amount of available plant food than in a northern state. With the long, warm seasons we have a more rapid and longer continued decomposition of the organic matter in the soil, with the result that a larger percentage of the plant foods in the soil becomes available during the season. It is this greater destruction of organic matter in the soils of

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\*There is a growing tendency of the Agricultural Experiment Stations to express plant food in the soil in terms of the essential elements themselves. The term "nitrogen" has already largely supplanted the term "ammonia", and likely the elements "phosphorus" and "potassium" will eventually replace the terms "phosphoric acid" and "potash". Should the phosphoric acid in the soil be desired the approximate amount can be obtained by multiplying the pounds of phosphorus by  $2 \frac{1}{3}$ .

the South that has resulted in their naturally having a small total supply of nitrogen.

While in Arkansas we have soils with as low as 2500 to 3000 pounds of nitrogen in the surface soil which still produce good crops and are properly considered fertile, still these same soils will not hold up long under continued cultivation unless steps are taken to keep up the supply of organic matter. Some of the sandy pine lands of South Arkansas give good yields for a few years after being cleared, even though they contain only small amounts of total plant food. This is due to the fact that a good portion of the total plant food contained is present in readily available form. In five or six years this readily available material is used and the yields begin to fall off rapidly unless proper systems of soil management are adopted.

### SOIL ACIDITY

When a soil contains little or no active lime it is "sour" and has an acid reaction, and when well supplied with lime the soil is alkaline in reaction. When there is just enough lime to neutralize any acidity the soil is neutral. The more acid a soil is shown to be, the more lime will be required for complete neutralization of the acid. The acidity of a soil may vary considerably over small areas. However, the acidity indicated in the description of the soil types, on following pages, is very likely close to the average conditions for each type.

### POTASSIUM

It is unfortunate that it is impossible to show the content of total potassium in these soils, as potassium is one of the elements of plant food needing careful attention. Sufficient analyses to determine the potassium content have been made in this state to show the need of work directed along this line. A few of these analyses are here given:

#### POTASSIUM IN 2,000,000 POUNDS OF SOIL.

| Source of Sample   | Surface<br>pounds | Subsoil<br>pounds |
|--------------------|-------------------|-------------------|
| Fayetteville ----- | 8300              | 8800              |
| Mena -----         | 9200              | 12400             |
| Danville -----     | 10600             | 15200             |
| Hope -----         | 3400              | 2000              |
| Imboden -----      | 19200             | 18600             |
| Lonoke -----       | 19800             | 18600             |
| Pine Bluff -----   | 31400             | 28800             |

From these results it will be seen that there is a wide variation in the potassium content of the different soils of the state. This soil from near Hope carries only 3400 pounds of potassium

in the surface seven inches of an acre, while the soil from near Pine Bluff carries nearly nine times as much, or over 31,000 pounds in the same amount of soil. With a supply such as found in this Pine Bluff soil, which is sufficient potassium to last several thousand years where usual sized crops are grown, it is not advised to add more potassium but to take steps to make available the potassium from this great supply.

It appears that the soils carrying the smallest amount of total potassium are found in the sandy lands of the Coastal Plain region and in the sandier lands of the hill section of the western part of the state. The lowland soils in the eastern portion of the state contain the largest total supply, as these soils represent to a large extent wash from the northern states where the soils are well supplied with potassium.

### CLASSIFICATION OF ARKANSAS SOILS

The most commonly occurring soil types in each area are listed.

#### UPLANDS FROM CONSOLIDATED MATERIALS. HILL SECTION.

##### LIMESTONE SOILS

##### 1. Cherty non-magnesian limestone soils.

|                                | Page |
|--------------------------------|------|
| Baxter gravelly silt loam..... | 23   |
| Baxter silt loam.....          | 24   |
| Clarksville stony loam.....    | 26   |

##### 2. Shaly limestone and magnesian limestone soils.

|                           |    |
|---------------------------|----|
| Hagerstown silt loam..... | 27 |
|---------------------------|----|

##### 3. Cherty limestone and magnesian limestone soils.

|                             |    |
|-----------------------------|----|
| Clarksville stony loam..... | 26 |
| Clarksville silt loam.....  | 27 |
| Lebanon silt loam.....      | 28 |

##### 4. Sandy limestone, dolomite and calcareous sandstone soils.

|                            |    |
|----------------------------|----|
| Izard fine sandy loam..... | 29 |
|----------------------------|----|

##### 5. Silty soils from chert-free limestone and dolomite.

|                           |    |
|---------------------------|----|
| Decatur silt loam.....    | 27 |
| Hagerstown silt loam..... | 27 |

##### 6. Gray soils from limestone and over-lying sandstone.

|                                 |    |
|---------------------------------|----|
| Baxter silt loam.....           | 24 |
| Boone very fine sandy loam..... | 25 |
| Clarksville silt loam.....      | 27 |

##### SANDSTONE AND SHALE SOILS.

##### 7. Dark clay soils from shale and thin-bedded limestone and sandy soils from calcareous sandstones.

|                          |    |
|--------------------------|----|
| Gasconade silt loam..... | 36 |
| Upshur loam.....         | 37 |

##### 8. Rough mountainous sandstone and shale soils.

|                                 |    |
|---------------------------------|----|
| Hanceville stony loam.....      | 31 |
| Hanceville loam.....            | 35 |
| Hanceville fine sandy loam..... | 33 |
| Rough stony land.....           |    |

## 9. Ridge and lowland sandstone and shale soils.

|                                      | Page |
|--------------------------------------|------|
| Conway silt loam.....                | 29   |
| Hanceville fine sandy loam.....      | 33   |
| Hanceville very fine sandy loam..... | 35   |
| Hanceville shale loam.....           | 32   |

## 10. Ouachita Mountain Region—sandstone and shale soils.

|                                      |    |
|--------------------------------------|----|
| Conway silt loam.....                | 29 |
| Hanceville stony loam.....           | 31 |
| Hanceville fine sandy loam.....      | 33 |
| Hanceville very fine sandy loam..... | 35 |
| Rough stony land.....                |    |

## 11. Ouachita Mountain Region—soils from sandstone, shale, slate, and thin-bedded limestone.

|                                 |    |
|---------------------------------|----|
| Hanceville stony loam.....      | 31 |
| Hanceville fine sandy loam..... | 33 |
| Rough stony land.....           |    |
| Talladega stony silt loam.....  | 27 |

## UPLANDS FROM UNCONSOLIDATED MATERIALS.

## 12. Silty loessial soils—Crowley's Ridge.

|                              |    |
|------------------------------|----|
| Memphis silt loam.....       | 38 |
| Memphis silty clay loam..... | 39 |

## 13. Gray sandy soils.

|                                       |    |
|---------------------------------------|----|
| Caddo fine sandy loam.....            | 39 |
| Caddo very fine sandy loam.....       | 40 |
| Norfolk fine sandy loam.....          | 47 |
| Norfolk sand.....                     | 46 |
| Orangeburg fine sandy loam.....       | 47 |
| Ruston fine sandy loam.....           | 49 |
| Ruston very fine sandy loam.....      | 51 |
| Susquehanna very fine sandy loam..... | 53 |
| Susquehanna fine sandy loam.....      | 52 |

## 14. Gray silt loams and very fine sandy loams containing considerable clay. Undulating to rolling topography.

|                                       |    |
|---------------------------------------|----|
| Ruston very fine sandy loam.....      | 51 |
| Susquehanna very fine sandy loam..... | 53 |
| Susquehanna silt loam.....            | 54 |
| Susquehanna clay.....                 | 55 |

## 15. Silt loams and clay soils usually gray. Includes areas of "Black land".

|                                     |    |
|-------------------------------------|----|
| Caddo silt loam.....                | 41 |
| Houston clay.....                   | 43 |
| Oktibbeha very fine sandy loam..... | 44 |
| Sumter clay.....                    | 51 |
| Susquehanna silt loam.....          | 54 |
| Susquehanna clay.....               | 55 |

## 16. Sandy and gravelly soils. Rolling topography.

|                                 |    |
|---------------------------------|----|
| Greenville gravelly loam.....   | 42 |
| Norfolk sand.....               | 46 |
| Norfolk fine sandy loam.....    | 47 |
| Orangeburg fine sandy loam..... | 47 |
| Ruston fine sandy loam.....     | 49 |

## TERRACE AND BOTTOM LANDS.

## 17. Northeastern Terrace.

|                               | Page |
|-------------------------------|------|
| Biscoe silt loam.....         | 67   |
| Calhoun silt loam.....        | 68   |
| Calhoun clay.....             | 69   |
| Crowley silt loam.....        | 69   |
| Lintonia fine sandy loam..... | 72   |
| Morse clay.....               | 73   |
| Olivier silt loam.....        | 74   |

## 18. South Arkansas Terraces.

|                        |    |
|------------------------|----|
| Caddo silt loam.....   | 41 |
| Crowley silt loam..... | 69 |
| Lufkin silt loam.....  | 45 |

## 19. Recent Alluvium.

## Small streams

## Hill section

## First bottom

|                       |    |
|-----------------------|----|
| Atkins silt loam..... | 56 |
| Huntington loam.....  | 57 |
| Pope silt loam.....   | 57 |

## Second bottom

|                      |    |
|----------------------|----|
| Waynesboro loam..... | 58 |
|----------------------|----|

## Coastal Plains

## First bottom

|                                   |    |
|-----------------------------------|----|
| Bibb very fine sandy loam.....    | 59 |
| Hannahatchee fine sandy loam..... | 60 |
| Ochlockonee silt loam.....        | 60 |
| Ochlockonee clay.....             | 60 |
| Trinity clay.....                 | 61 |

## Second bottom

|                             |    |
|-----------------------------|----|
| Cahaba fine sandy loam..... | 61 |
| Leaf silt loam.....         | 62 |

## Large streams.

Considerable material from glacial and loessial areas. (Mississippi and white River bottoms).

## First bottom

|                                 |    |
|---------------------------------|----|
| Sarpy very fine sandy loam..... | 62 |
| Sarpy silty clay loam.....      | 63 |
| Sharkey clay.....               | 63 |
| Waverly silt loam.....          | 65 |
| Waverly clay.....               | 66 |
| Yazoo silt loam.....            | 66 |
| Yazoo silty clay loam.....      | 67 |

Considerable material from western plains. (Arkansas and Red River bottoms).

## First bottom

|                                    |    |
|------------------------------------|----|
| Miller clay.....                   | 75 |
| Portland very fine sandy loam..... | 75 |
| Portland clay.....                 | 76 |
| Yahola very fine sandy loam.....   | 77 |
| Yahola silt loam.....              | 78 |

## Second bottom

|                                    | Page |
|------------------------------------|------|
| Bastrop clay.....                  | 78   |
| Brewer very fine sandy loam.....   | 79   |
| Brewer silt loam.....              | 80   |
| Brewer clay.....                   | 80   |
| Muskogee very fine sandy loam..... | 81   |
| Muskogee silt loam.....            | 81   |
| Reinach silt loam.....             | 82   |

## DESCRIPTION OF SOIL TYPES

## Limestone Soils

## BAXTER GRAVELLY SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction         |
|----------------------------------|---------------------|--------|------------------|
|                                  | Pounds              | Pounds |                  |
| In 2,000,000 pounds surface soil | 1600                | 380    | Neutral to acid. |
| In 2,000,000 pounds subsoil      | No sample.          |        |                  |

The surface soil of the Baxter gravelly silt loam is a light brown or grayish brown silt loam containing varying amounts of gravel. In some places the gravel is of such size and quantity that it interferes with cultivation very little, while again as the type grades into the stony loam type the amount and size of the gravel makes working the soil difficult. The gravel is chert or flint varying in color from pure white to reddish brown.

The subsoil consists of a mass of irregular chert mixed with red clay loam or clay. Ordinarily it is almost impossible to bore far into the subsoil with a soil auger.

The Baxter gravelly silt loam occupies from undulating to rolling topography. Where it is found on the divides the gravel is usually not much of a factor, but where found on the steep slopes the type approaches the stony loam.

Drainage as a rule is excessive, and considerable damage is done by erosion. On some of the steeper cultivated slopes the damage done by erosion would be far greater were it not for the presence of the gravel on the surface.

The soil's supply of both nitrogen and phosphorus is low, and where the gravel is of small size and little erosion is going on the increase of both these elements should be contemplated. Growing legumes and turning organic matter into the soil should be practiced.



Fruit, both small and tree fruits, do well on this type where the subsoil is not too stony, and likely with the extension of the grape industry in northwest Arkansas a considerable acreage will be given over to this crop.

#### BAXTER SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                             |
|----------------------------------|---------------------|--------|--------------------------------------|
|                                  | Pounds              | Pounds |                                      |
| In 2,000,000 pounds surface soil | 2200                | 560    | Neutral to strongly acid.            |
| In 2,000,000 pounds subsoil      | 1580                | 340    | Slightly acid to very strongly acid. |

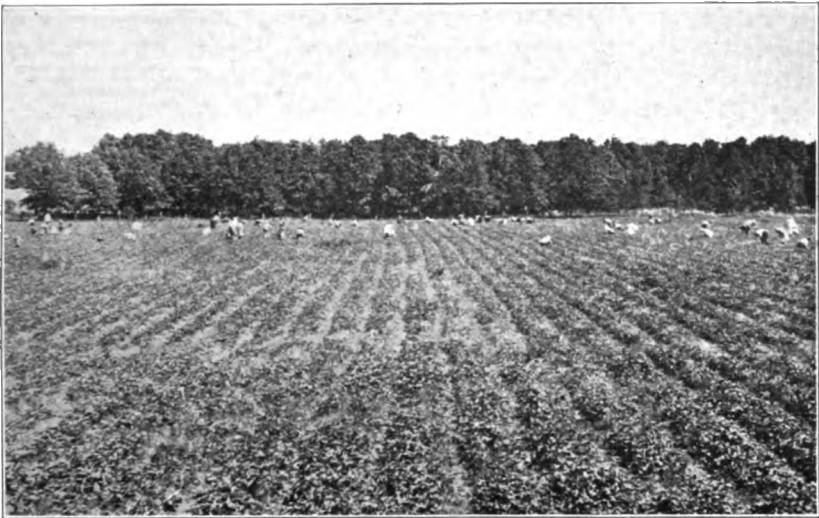
The Baxter silt loam is a light brown to brown silt loam which passes at from 8 to 10 inches into a yellowish brown or reddish brown silty clay loam. The subsoil usually has a good physical condition, and only occasionally is there some compaction which is usually associated with more or less mottling.

The Baxter silt loam is undulating, with sufficient relief as a general rule to give it good drainage.

The soil is one of the soils best adapted to diversified farming to be found in north Arkansas. It is one of the stronger upland soils having a fair supply of total nitrogen, though rather low in total phosphorus. The supply of phosphorus must be increased in order to obtain most profitable crops. More attention should be paid to legume crops. Originally clover did well on most of the Baxter soils, but it is becoming more and more difficult to obtain a good stand. The correction of the acidity on the more acid portions of the type will help to make profitable yields of clover possible. The use of one or two tons of ground limestone per acre where the type is acid is recommended. The addition of some phosphorus carrying materials will also increase the growth of legumes, and this practice should be extended. Red clover should probably have the preference in north Arkansas, though peas and soy beans may be fitted in as summer legumes.

If bone meal or acid phosphate has been used on fall seeded small grains the use of a small amount of soluble nitrogen as the crops start off in the spring will pay on the more worn areas.

Though this type is well adapted to general farming a considerable portion in northwest Arkansas is in orchards, and the returns from these orchards show the adaptation of the type to apples. It has been found that soluble nitrogen can be applied to producing orchards with profit. A considerable acreage is also devoted to the production of strawberries.



Although well adapted to general farming, many acres of the Baxter silt loam are devoted to strawberry production.

#### BOONE VERY FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        |                        |
|----------------------------------|---------------------|--------|------------------------|
|                                  | Pounds              | Pounds | Reaction               |
| In 2,000,000 pounds surface soil | 1370                | 320    | Slightly acid to acid. |
| In 2,000,000 pounds subsoil      | 1200                | 320    | Acid to strongly acid. |

The Boone very fine sandy loam is a yellowish gray to gray very fine sandy loam which passes at from 5 to 8 inches into a light yellow material of similar texture. With increasing depth the soil material becomes heavier, passing into a yellow fine sandy clay frequently mottled with red and gray. It is not uncommon to find the underlying sandstone within 3 feet of the surface.

The type occupies from undulating to rolling topography, and is naturally well drained.

The supply of both nitrogen and phosphorus in this soil is low. The crop that this soil is capable of producing where some attention is paid to maintaining fertility is surprising when the low content of plant food is considered. The growing of legumes, using acid phosphate to increase their growth, and the use of lime on the more acid portions of the type, will increase the productivity of this soil.

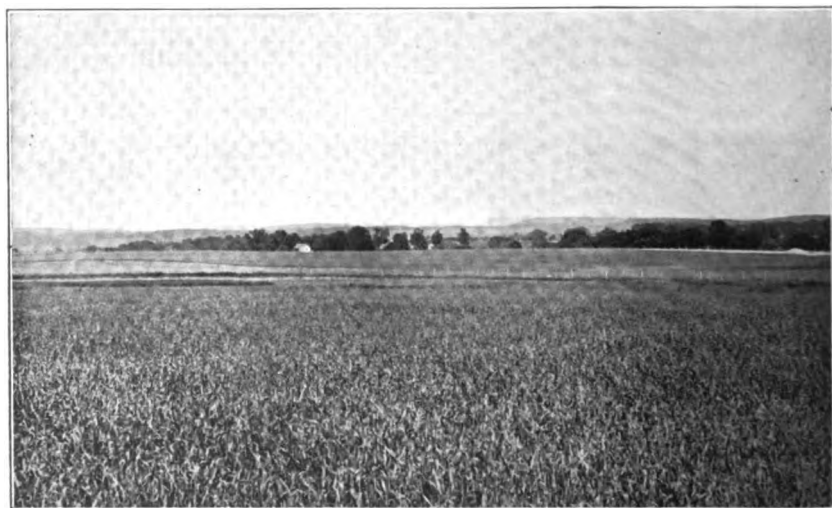
## CLARKSVILLE STONY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction         |
|----------------------------------|---------------------|--------|------------------|
|                                  | Pounds              | Pounds |                  |
| In 2,000,000 pounds surface soil | 1020                | 400    | Neutral to acid. |
| In 2,000,000 pounds subsoil      | No sample.          |        |                  |

The soil of the Clarksville stony loam has much the same appearance as the silt loam except for the large amount of flint or chert fragments found, not only on the surface but throughout the soil section. Usually there is more flint on the immediate surface than is found at lower depths until the only partially decomposed rock is reached.

Some areas of the stony loam are sufficiently free of stone and gently sloping enough that cultivated farm crops such as corn are grown. Over most of the type, however, this would be impossible, although on much of this stonier and steeply lying land strawberries and grapes are grown. Where the chert fragments are not too large some strawberry growers prefer this type to the Clarksville silt loam, which is relatively free from stone, as the berries are freer from dirt on the gravelly and stony soil. The yields and quality of the strawberries grown on some of this flinty soil are remarkable.

This soil is not well supplied with plant food, and where fruits are grown the need of improvement is quickly felt, with the result that a large amount of manure from Kansas City has



Baxter and Clarksville soils, derived from cherty limestone. The higher ridges in the background are capped by sandstone.

been shipped into northwest Arkansas to be used on this and related types.

#### CLARKSVILLE SILT LOAM

|                                  | Nitrogen Phosphorus |        |                                 |
|----------------------------------|---------------------|--------|---------------------------------|
|                                  | Pounds              | Pounds | Reaction                        |
| In 2,000,000 pounds surface soil | 1920                | 540    | Neutral to acid.                |
| In 2,000,000 pounds subsoil      | 1260                | 380    | Slightly acid to strongly acid. |

The surface soil of the Clarksville silt loam varies from a light gray to a light brownish gray. The subsoil is a yellow or a reddish yellow heavy silt loam or silty clay loam. This soil is very closely related to the Baxter silt loam, the chief difference readily noted being that the Baxter subsoil is red.

The Clarksville silt loam usually occupies the top of the ridges in the section where found, this type giving way to the Baxter and Clarksville stony loams on the steeper hillsides that slope to the stream courses. It is a good general farming soil and can be brought to a high state of cultivation. Its adaptation and fertilizer requirements are similar to the Baxter silt loam. As it does not carry as much plant food naturally as the Baxter soil the need of improvement is more apparent.

#### DECATUR SILT LOAM

|                                  | Nitrogen Phosphorus |        |                                      |
|----------------------------------|---------------------|--------|--------------------------------------|
|                                  | Pounds              | Pounds | Reaction                             |
| In 2,000,000 pounds surface soil | 1600                | 520    | Neutral to slightly acid.            |
| In 2,000,000 pounds subsoil      | 840                 | 400    | Slightly acid to very strongly acid. |

The surface soil of the Decatur silt loam is a gray silt loam which passes rather quickly into a yellow or yellowish red material of the same texture. Usually at 10 to 12 inches a deep red clay loam or clay is found.

Chert fragments are found scattered over the surface, in some places sufficient gravel being found to produce a gravelly loam. More chert is found in the subsoil.

The fertility of this soil may be increased by growing legumes and the use of phosphorus carrying fertilizers. On much of the type it will be necessary to apply some lime before best results from legumes can be obtained. With ledges of limestone rather generally distributed throughout the region, ground limestone should be easily obtained.

#### HAGERSTOWN SILT LOAM

|                                  | Nitrogen Phosphorus |        |                  |
|----------------------------------|---------------------|--------|------------------|
|                                  | Pounds              | Pounds | Reaction         |
| In 2,000,000 pounds surface soil | 2700                | 500    | Neutral to acid. |
| In 2,000,000 pounds subsoil      | 2380                | 520    | Neutral to acid. |

The Hagerstown silt loam is a brown silt loam which passes at from 8 to 12 inches into a yellowish brown or reddish brown silt loam containing considerable clay, or a clay loam. The deeper subsoil usually is a reddish brown or dull red clay. As a rule this soil is fairly free from flint or chert, although occasionally small chert gravel occurs, not in sufficient quantity, however, to seriously interfere with cultivation.

The type occupies undulating to gently rolling topography, and as a whole is well drained. This soil is one of the strongest upland soils found in north Arkansas, and is highly prized. One of the largest continuous areas of this soil is found in the vicinity of Berryville.

The Hagerstown silt loam is fairly well supplied with total nitrogen, and many farmers on this type have taken steps to maintain this supply. Clover has been grown in considerable quantity for years, but of late clover is beginning to fail on portions of the type. This condition will continue to grow worse unless these lands are limed.

Some of these lands are still neutral and clover can be grown with a fair degree of success. Other portions are becoming acid, and this acidity should be corrected. Limestone is usually easily found, so that obtaining ground limestone should not be difficult.

In addition to the use of lime and the continued use of clover and other legumes, the use of phosphorus carrying fertilizers such as acid phosphate and rock phosphate, will prove profitable.

#### LEBANON SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                  |
|----------------------------------|---------------------|--------|---------------------------|
|                                  | Pounds              | Pounds |                           |
| In 2,000,000 pounds surface soil | 1640                | 400    | Acid.                     |
| In 2,000,000 pounds subsoil      | 920                 | 320    | Neutral to strongly acid. |

The Lebanon silt loam is a light gray to light brown floury silt loam underlain by a pale yellow to almost white silt loam. Usually the subsoil at from 16 to 24 inches becomes a compact gray or drab clay mottled with brown, although sometimes a compact silt layer is found. This compact layer may be only 4 inches to a foot in thickness, and below it the subsoil may be fairly open, yet this layer very seriously interferes with the movement of water through the soil, with the result that crops can not withstand drought.

The Lebanon silt loam is flat to undulating and much of the type is not naturally well drained, even though it is usually found on the flat-topped ridges.

The type is not well supplied with plant food and is acid. The use of lime and phosphorus carrying materials to increase crops and crop residues which may be turned into the soil to

increase the organic matter content should be adopted. The addition of organic matter will have a decidedly beneficial effect on the working qualities of this soil.

#### IZARD FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction            |
|----------------------------------|---------------------|--------|---------------------|
|                                  | Pounds              | Pounds |                     |
| In 2,000,000 pounds surface soil | 640                 | 320    | Very slightly acid. |
| In 2,000,000 pounds subsoil      | 540                 | 340    | Strongly acid.      |

The Izard fine sandy loam is a light yellowish gray fine sandy loam, which passes at from 5 to 8 inches into a yellowish red or red heavy sandy loam. The subsoil usually becomes a deeper red, and the clay content increases with depth until the only partly decomposed sandstone is reached.

The Izard fine sandy loam is very similar in appearance to the Hanceville fine sandy loam, a soil formed from sandstone and shale. The Izard fine sandy loam is formed by the breakdown of sandstone and limestone, principally the St. Peters sandstone.

The Izard fine sandy loam is not well supplied with either nitrogen or phosphorus; in fact its nitrogen content is very low. The use of legumes and the addition of phosphates is necessary for best results. For the present it will pay to use a complete fertilizer on cotton. One analyzing approximately 9-3-3 should give good results.

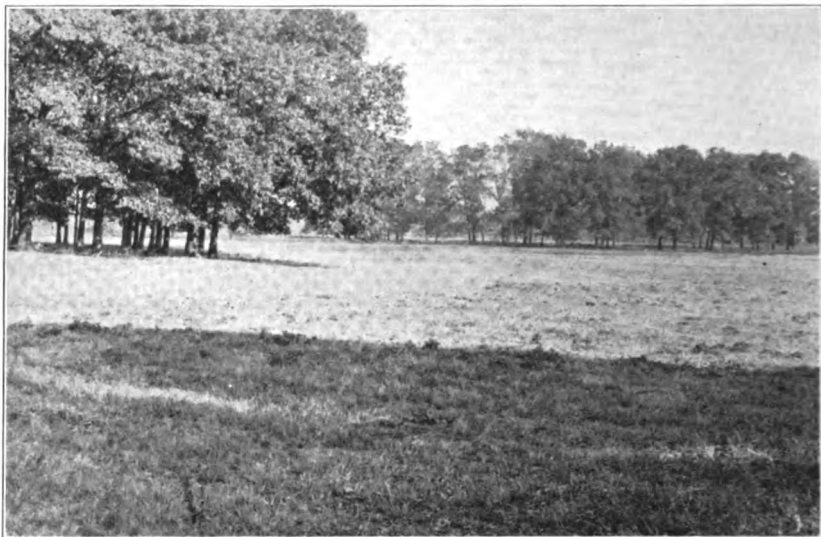
#### Sandstone and Shale Soils

##### CONWAY SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                    |
|----------------------------------|---------------------|--------|-----------------------------|
|                                  | Pounds              | Pounds |                             |
| In 2,000,000 pounds surface soil | 1840                | 660    | Acid to very strongly acid. |
| In 2,000,000 pounds subsoil      | 1460                | 620    | Very strongly acid.         |

The surface soil of the Conway silt loam consists of a light grayish brown to yellowish gray silt loam. This material passes into a yellow gray or yellow silt loam which grades with depth into a yellowish silty clay loam to silty clay. The lower subsoil becomes very compact and usually consists of a silty clay mottled with yellow and gray, frequently containing a compact layer of dark colored concretions. Where the concretionary layer is not found within 36 inches of the surface it may often be found deeper in the substratum. This layer where a large portion of the material consists of ferruginous concretions may be only a few inches to 2 or even 3 feet in thickness. Iron concretions are rather numerous in the surface and throughout the 3-foot profile.

The Conway silt loam is the typical valley land, its topography varying from flat to undulating. Dome-shaped mounds 1 to 4 feet high are frequently a conspicuous feature on this type.



The Conway silt loam is the typical flat-lying valley land of the sandstone and shale country. The clump of trees in the left foreground is growing on a low knoll rather characteristic of the type.

The type as a rule occupies lower, flatter areas than the adjacent Hanceville soils, and is not nearly so well drained; in fact over much of the type drainage is only fair to poor.

Over large areas water stands for a considerable period after rains, and the water table is never at a great distance below the surface. The almost impervious subsoil does not permit ready downward movement of water, and the flat surface does not encourage surface runoff. These lower, wetter areas are known as "slashes" and "crawfish land". The necessity of draining a large portion of the type is apparent.

The Conway silt loam is better stocked with plant food than the Hanceville soils, containing considerable more nitrogen than any of the Hanceville soils and as much or more phosphorus. The poor drainage and poor physical condition of the subsoil of the Conway tend to offset the larger store of plant food, as this almost impervious subsoil not only hinders percolation of water, but also retards upward movement of capillary water during dry weather so that crops do not stand drought.

The use of acid phosphate with manure or alone where legumes are grown and fed on the land, or turned under as green manure, is recommended for corn or cotton on the better drained areas. Where legumes or manure are not used some nitrogen may well be used along with the acid phosphate on the better drained land where cotton is grown.

The use of green manures should be widely extended. Applications of 1 to 1½ tons of ground limestone will prove profitable on the better drained lands.

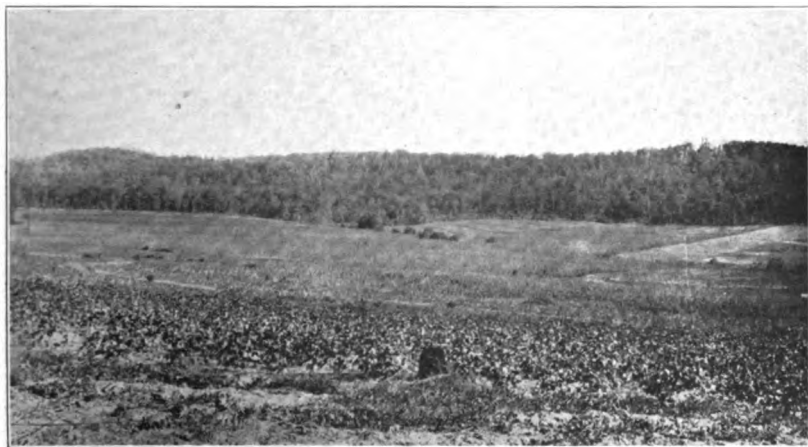
#### HANCEVILLE STONY LOAM

|                                  | Nitrogen<br>Pounds | Phosphorus<br>Pounds | Reaction       |
|----------------------------------|--------------------|----------------------|----------------|
| In 2,000,000 pounds surface soil | 1060               | 460                  | Slightly acid. |
| In 2,000,000 pounds subsoil      | 900                | 480                  | Acid.          |

The Hanceville stony loam occupies most of the rougher land in the hill section outside of the rough stony land areas, which are too steep and broken to be of much value except for forestry. Most of the stony loam is still timbered and a good portion is included in the National Forest Reserve. Much of the type should always remain timbered for attempts at clearing and cultivating a large portion of it would result in the loss of the soil through erosion and much wasted effort.

The soil of the Hanceville stony loam is a light brown or brownish gray silt loam to loam. The subsoil is a yellowish red to red clay loam or clay, usually fairly good structure. The soil itself compares favorably with the other soils of this series, but the low agricultural value as compared with the other Hanceville soils is due to its rugged topography and to the large amount of sandstone rock scattered over the surface, which makes cultivation difficult in some places and impossible in others.

In the more favored areas where there are relatively few rocks and the land is not too rolling, work toward building up the soil may well be undertaken. The first step taken in bringing



In the Ouachita region there are attractive valleys. The steeper hillsides are stony and are left in timber. Hanceville soils.



the land under cultivation should be the construction of terraces to check washing. This should be followed with a liberal use of green manures to increase the organic matter content of the soil. Although the phosphorus content of the soil is low the general use of phosphorus carrying fertilizers on this type is not advised, as the erosion which will go on in spite of careful farming will gradually remove the surface soil and phosphorus will be secured from lower depths.

Much of the type is located at a considerable distance from railroads. Some of the better areas within a reasonable hauling distance of a railroad may be used for the production of fruit, especially strawberries. Where such intensive farming can be practiced the use of commercial fertilizers should be considered.

#### HANCEVILLE SHALE LOAM

|                                  | Nitrogen Phosphorus |        |                             |
|----------------------------------|---------------------|--------|-----------------------------|
|                                  | Pounds              | Pounds | Reaction                    |
| In 2,000,000 pounds surface soil | 1380                | 680    | Slightly acid to acid.      |
| In 2,000,000 pounds subsoil      | 980                 | 560    | Acid to very strongly acid. |

The Hanceville shale loam is a reddish brown loam to silt loam, usually grading with depth into a rather friable yellowish red to red silty clay, which quickly passes into a rather stiff red clay.

Fragments of shale and shaly sandstone are found scattered about over the surface of the type and are also encountered in the soil. Where large quantities of shale are found on the surface the bed rock will usually be found within the upper 3-foot section.

The type usually is found toward the foot of slopes where the shale underlying the sandstone has been exposed on the surface. In this position it usually occupies only narrow belts.

The shale loam is better supplied with both nitrogen and phosphorus than any of the other Hanceville soils. The amounts found, however, are low when compared with the amounts found in a fertile soil. The shallow depth at which the parent rock is frequently found and the texture and structure of the soil make crops on this type greatly affected by drought. These physical defects offset the advantage of the larger amount of plant food found in this type.

By increasing the organic matter content of this soil through the growing and turning under of legumes, the nitrogen supply can be built up and the water holding capacity of the soil can be increased. Deeper plowing will furnish more soil reservoir to hold water.

Crops grown on this type will show response to applications of phosphates and addition of nitrogen.

## HANCEVILLE FINE SANDY LOAM

|                                  | Nitrogen<br>Pounds | Phosphorus<br>Pounds | Reaction                        |
|----------------------------------|--------------------|----------------------|---------------------------------|
| In 2,000,000 pounds surface soil | 1080               | 420                  | Very slightly acid to acid.     |
| In 2,000,000 pounds subsoil      | 840                | 440                  | Slightly acid to strongly acid. |

The surface soil of the Hanceville fine sandy loam is a light brown to grayish brown fine sandy loam of good texture, mealy and as a rule easily worked.

The subsoil is a yellow to yellowish red fine sandy loam to sandy clay, passing into a yellowish red to red sandy clay to clay. The subsoil, and surface as well, contains more or less loose sandstones, and frequently solid rock is found within three feet of the surface.



The lowland phase of the Hanceville fine sandy loam offers a pleasing appearance.

The Hanceville fine sandy loam is found on the flatter mountain tops and again in the lower undulating and gently rolling lands at the foot of the slopes, the steep mountain slopes being covered largely by rough stony land and the stony loam. The subsoil of the lowland phase is usually somewhat more compact than the subsoil of the higher lying portions of the type.

Practically all of this type is naturally well drained, in fact

on much of it the drainage is too rapid and complete. In many cultivated fields the original surface soil has been removed by erosion, leaving the subsoil exposed as "clay points", and occasionally the underlying rock has been uncovered. These more rolling areas, which are under cultivation, should be terraced as it is not profitable to build up a soil only to let it wash away.



Erosion is serious on a considerable portion of the Hanceville fine sandy loam.

The soil is poorly supplied with organic matter and with both nitrogen and phosphorus. Being of good texture the soil does respond readily to good treatment. Organic matter should be added to this soil by all possible means. Large portions may well be given over to grass. More live stock should be brought into areas where this soil is the prevailing type. As the organic matter content of the soil is increased it will be profitable to increase the amount of phosphorus available to the crop being grown by using acid phosphate, bone meal, or some other fertilizing material high in phosphorus.

For the present a complete fertilizer will usually give best returns. A fertilizer analyzing approximately 10-3-2, used at the rate of 250 to 400 pounds per acre, should give a profitable increase when used for cotton.

**HANCEVILLE VERY FINE SANDY LOAM**

|                                  | Nitrogen<br>Pounds | Phosphorus<br>Pounds | Reaction                    |
|----------------------------------|--------------------|----------------------|-----------------------------|
| In 2,000,000 pounds surface soil | 1200               | 500                  | Very slightly acid to acid. |
| In 2,000,000 pounds subsoil      | 820                | 380                  | Acid to very strongly acid. |

The Hanceville very fine sandy loam is a grayish brown to reddish brown very fine sandy loam, mellow, and easily kept in good tilth. Only when the organic matter content is very low and the land is worked when very wet does this soil become cloddy.

The subsoil is a yellowish red, very fine sandy loam to sandy clay, passing with depth into a yellowish red to red sandy clay or clay.

The type as a rule is only gently rolling, so that the major portion of the type is well adapted to general farming operations.

The agricultural value of the Hanceville very fine loam is about equal to that of the Hanceville loam, into which it grades. The stock of plant food in the two soils is approximately the same, and the methods of improvement should be similar. One advantage possessed by the very fine sandy loam is the fact that the soil may be worked through a wider range of moisture content without injury to the structure of the soil than is possible with the loam.

Being a splendid soil physically this soil responds readily to use of organic manures coupled with the use of acid phosphate.

A fertilizer carrying both nitrogen and phosphorus can be profitably used for cotton.

The use of ground limestone at the rate of one ton per acre on this soil where any large amount of erosion has been stopped, will prove profitable where legumes affected by soil acidity are to be grown.

**HANCEVILLE LOAM**

|                                  | Nitrogen<br>Pounds | Phosphorus<br>Pounds | Reaction                  |
|----------------------------------|--------------------|----------------------|---------------------------|
| In 2,000,000 pounds surface soil | 1020               | 600                  | Neutral to slightly acid. |
| In 2,000,000 pounds subsoil      | 680                | 540                  | Acid.                     |

The surface soil of the Hanceville loam is a light brown to grayish brown mellow loam. The immediate surface is frequently a dark brown, but the color changes rapidly with depth into a yellow or yellow gray. The subsoil is a yellowish red to red silty clay to clay, frequently mottled with lighter colors, even gray.

Large areas are sometimes found where the soil is practic-

ally free from stones, this condition naturally being found on the more level lying portions. Over most of the type, however, small fragments of both sandstone and shale are found rather generally distributed throughout both surface and subsoil. Not infrequently on the steeper slopes or narrow ridges, where erosion is active, bed rock is found within 3 feet of the surface.

The Hanceville loam contains approximately the same amount of nitrogen as the fine sandy loam and the stony loam, but is better supplied with total phosphorus. It is considered one of the best soils of the Hanceville series,, for although it does not contain as much plant food as the shale loam, still its ability to withstand drought better than the shale loam offsets the lower content of plant food.

Terracing the rolling areas, deeper plowing, growing and turning into the soil legume crops such as cowpeas, to increase the organic matter and nitrogen supply, and the use of phosphorus carrying fertilizers, are some of the first steps to adopt to improve this land.

The type is neutral to slightly acid in reaction. The use of lime is not to be recommended except on land where excessive washing has been stopped. On terraced lands where good farming is being carried on ground limestone at the rate of one ton per acre may well be used.

#### GASCONADE SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                    |
|----------------------------------|---------------------|--------|-----------------------------|
|                                  | Pounds              | Pounds |                             |
| In 2,000,000 pounds surface soil | 2940                | 500    | Acid.                       |
| In 2,000,000 pounds subsoil      | 2080                | 340    | Acid to very strongly acid. |

The surface soil of the Gasconade silt loam is a brownish gray or brown silt loam. The subsoil is usually a rather compact silty clay loam of silty clay. The color of the subsoil is rather variable, sometimes continuing a brown or dark gray for 30 inches or more. Where the subsoil is very compact the upper subsoil is likely to be a light gray, this material resting on a gray or drab compact silty clay loam which is frequently streaked with red and rusty brown.

This soil is formed from the breakdown of a mixture of shale and limestone. In some cases the shale has predominated, while in others the material was mainly limestone.

The type is generally flat and rather poorly drained. Low circular mounds from 1 to 3 feet high and 15 to 30 feet in diameter are commonly found on the type, these mounds interfering with surface drainage which makes the type even more poorly drained than it otherwise would be. Drainage is of first importance on much of this type. A considerable portion of the type,

especially toward the western border of the State, was originally prairie.

The soil is fairly well supplied with nitrogen, but is low in total phosphorus content. Where drainage has been taken care of the use of phosphates and lime will prove profitable.

#### TALLADEGA STONY SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction |
|----------------------------------|---------------------|--------|----------|
|                                  | Pounds              | Pounds |          |
| In 2,000,000 pounds surface soil | 1200                | 460    | Acid.    |
| In 2,000,000 pounds subsoil      | 780                 | 600    | Acid.    |

The soil of the Talladega stony silt loam is a gray to brownish gray fine sandy loam to silt loam. Stones of varying size and amount are scattered over the surface and found through the soil. The rock fragments are principally fine-grained sandstones, quartzite, quartz, and slaty shales.

The subsoil is a yellowish red to red silty clay loam, which passes with depth into a clay of similar color. Both the surface and subsoil have a characteristic greasy feel, this being more noticeable in the subsoil. The subsoil is inclined to be close, affording little water holding capacity.

The soil is derived from rocks that have been subjected to great heat and pressure in the region of intense folding in the Ouachita Mountain Section.

While this soil is as well supplied with total nitrogen and phosphorus as the corresponding Hanceville soil, the physical makeup of the Hanceville soil makes it more productive. The more nearly rock-free portions of the type that are under cultivation may be improved by terracing, deeper plowing, adding organic matter and the use of small amounts of acid phosphate.

A large portion of this type may well be allowed to remain in forest.

#### UPSHUR LOAM

|                                  | Nitrogen Phosphorus |        | Reaction               |
|----------------------------------|---------------------|--------|------------------------|
|                                  | Pounds              | Pounds |                        |
| In 2,000,000 pounds surface soil | 1160                | 400    | Slightly acid.         |
| In 2,000,000 pounds subsoil      | 840                 | 250    | Slightly acid to acid. |

The Upshur loam is a brown to reddish brown loam, which passes at from 6 to 10 inches into a brownish red to red clay loam or clay. This soil is formed mainly from calcereous sandstone and some shale.

The type is usually undulating to gently rolling, and on the whole drainage is good. The Upshur fine sandy loam, a closely associated type of very similar plant food content, usually is found on the flat hill or mountain tops and the loam at the foot of the hills and on the hillsides where not too steep. When the

hillsides are very steep the stony loam or rough stony land is found.

The Upshur loam is not well supplied with plant food. Although not as well stocked with plant food as the Baxter and Clarksville soils which lie just to the north, this soil is suited to much the same type of farming. The need of taking good care of the land becomes apparent sooner than on these other soils. This soil, however, is more easily worked and gives quick response to good treatment.

The use of organic manures and of acid phosphate is very important. The use of some potash on areas intensively cultivated, such as strawberries and sweet potatoes, will likely prove profitable. Applications of lime will pay on the more acid por- of the type where the distance of haul is not too great.

### Loessial Soils

#### MEMPHIS SILT LOAM

|                                  | Nitrogen Phosphorus |        |                     |
|----------------------------------|---------------------|--------|---------------------|
|                                  | Pounds              | Pounds | Reaction            |
| In 2,000,000 pounds surface soil | 1740                | 800    | Strongly acid.      |
| In 2,000,000 pounds subsoil      | 1060                | 880    | Very strongly acid. |

The surface soil of the Memphis silt loam is a yellow gray to yellow brown silt loam, which passes at from 6 to 8 inches into a yellow silt loam, this material giving way with depth to a red-dish yellow, yellow, or dull yellow silty clay loam to silty clay. On areas not as well drained as the average, and around the heads of draws, there may be considerable mottling of gray in the lower subsoil.

The Memphis silt loam is the most commonly occurring type found on Crowley's Ridge. The parent material is loess, a wind-blown deposit. It occupies undulating to rolling topog-raphy. It is usually found capping the Ridge unless it has been removed by erosion. It also is found at lower elevations where a considerable portion of it is reworked material. Small areas of similar soil are found on the hills along the border line be-tween the hill section and the lowlands.

Both surface and under-drainage is good over most of the type. Erosion is doing a large amount of damage where allowed to go unchecked.

The soil is not well supplied with either total nitrogen or phosphorus, and steps should be taken to increase the soil's content of both these elements. The increase of the organic matter content will help to hold moisture and aid in checking erosion.

Where fertilizing cotton it will be well to use a complete fertilizer until the organic matter content has been increased. A

fertilizer analyzing approximately 9-3-2, used at the rate of 400 pounds per acre, will give good returns on cotton.

The soil is strongly acid. The use of two tons of ground limestone as an initial application is advisable, where erosion has been taken care of and permanent soil improvement is contemplated.

#### MEMPHIS SILTY CLAY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction            |
|----------------------------------|---------------------|--------|---------------------|
|                                  | Pounds              | Pounds |                     |
| In 2,000,000 pounds surface soil | 1540                | 440    | Strongly acid.      |
| In 2,000,000 pounds subsoil      | 1410                | 480    | Very strongly acid. |

The Memphis silty clay loam is a reddish brown to yellowish brown silty clay loam, which passes rather quickly at from 3 to 6 inches into a yellowish red to reddish brown silty clay which becomes more compact with depth.

The Memphis silty clay loam occupies the steeper slopes on Crowley's Ridge, and in large measure is the result of the almost complete or entire removal of the surface Memphis silt loam, leaving somewhat modified subsoil material exposed on the surface. Erosion is still active over a large portion of the type, and the checking of this erosion demands first attention.

The soil is not well supplied with total nitrogen or phosphorus. The analyses would indicate that there is approximately only one-half as much phosphorus in the Memphis silty clay loam as in the Memphis silt loam, probably due to the larger amount of Coastal Plain material in the silty clay loam. The soil's content of both nitrogen and phosphorus should be increased. The soil is strongly acid. When erosion is taken care of and soil improvement is taken up some lime may well be used along with the fertilizer.

#### Coastal Plain Soils

##### CADDO FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction            |
|----------------------------------|---------------------|--------|---------------------|
|                                  | Pounds              | Pounds |                     |
| In 2,000,000 pounds surface soil | 960                 | 150    | Strongly acid.      |
| In 2,000,000 pounds subsoil      | 420                 | 130    | Very strongly acid. |

The surface soil of the Caddo fine sandy loam consists of a fine sandy loam or loamy fine sand, which passes at from 5 to 8 inches into a pale yellow very fine sandy loam or fine sandy loam, this material grading with depth into a yellow or reddish yellow fine sandy clay usually mottled with gray. Very frequently in the lower subsoil the material becomes rather compact and rather impervious to water. Iron concretions are frequently found in the lower subsoil.



The Caddo fine sandy loam is found associated with the Caddo very fine sandy loam, occupying somewhat depressed areas in the uplands. As a general rule it is somewhat better drained than the very fine sandy loam. Both of these Caddo types are referred to as "crawfishy" land where the drainage is not good.

This type is very poorly supplied with both total nitrogen and phosphorus. While drainage is necessary over much of the type before profitable yields can be obtained, even after thorough drainage has been accomplished profitable yields can not be maintained for many years, without increasing the supply of plant food. With these small total supplies it is absolutely necessary that mineral plant food be applied to this soil. Complete fertilizers will give best returns.

#### CADDO VERY FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                             |
|----------------------------------|---------------------|--------|--------------------------------------|
|                                  | Pounds              | Pounds |                                      |
| In 2,000,000 pounds surface soil | 1140                | 200    | Strongly acid to very strongly acid. |
| In 2,000,000 pounds subsoil      | 740                 | 160    | Very strongly acid.                  |

The surface soil of the Caddo very fine sandy loam is a yellowish gray to pale yellow very fine sandy loam, which passes at from 5 to 7 inches into a pale yellow, heavy, very fine sandy loam, this passing with depth into a yellow or yellow and gray mottled sandy clay or sandy loam. The lower subsoil usually becomes a rather compact silty clay, mottled with gray, yellow, and dull red.

The Caddo very fine sandy loam is found rather widely distributed throughout the Coastal Plain section. The areas



There is still considerable virgin timber in South Arkansas. Thousands of acres of Caddo very fine sandy loam support a valuable timber growth.

are usually small, usually occupying the lower lying slopes and around the heads of shallow drainage ways. As a general rule the type is only fairly well drained.

The type is not well supplied with total nitrogen and contains only a very small amount of total phosphorus. Where thorough drainage of this type has been accomplished, the use of highly phosphatic fertilizers is desirable. Along with this should go the increase of the total nitrogen and organic matter supplies of the soil. In building up this land it would be very desirable to use a complete fertilizer for a few years at least. A fertilizer analyzing approximately 9-3-3, used at the rate of 400 pounds per acre is to be recommended for cotton, using a somewhat smaller amount for corn.

#### CADDO SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                             |
|----------------------------------|---------------------|--------|--------------------------------------|
|                                  | Pounds              | Pounds |                                      |
| In 2,000,000 pounds surface soil | 1500                | 280    | Strongly acid to very strongly acid. |
| In 2,000,000 pounds subsoil      | 740                 | 200    | Very strongly acid.                  |

The surface soil of the Caddo silt loam is a gray or yellowish gray silt loam, passing at from 6 to 10 inches into a pale yellow or mottled yellow and gray silty clay loam, which grades with depth into a rather compact silty clay loam or silty clay, mottled with yellow and gray. The lower subsoil frequently carries streaks of iron concretionary material.



The Caddo silt loam is generally flat although numerous mounds occur. Where cleared or the timber growth is not too heavy good pasturage is obtained.

The Caddo silt loam frequently occurs associated with the Lufkin silt loam in the flatwoods country. The topography is generally flat, although low circular mounds from one foot to four feet high are a conspicuous feature of the landscape. The

soil on these mounds is usually of a coarser texture than the soil in the intervening spaces, the soils on the mounds being usually a fine sandy loam or very fine sandy loam. These mounds accentuate the poor drainage conditions of the type, as the water quickly runs off the mounds and accumulates in the intervening lower spots. Under natural conditions the type as a whole is only poorly drained. The Caddo silt loam is not well supplied with either total nitrogen or phosphorus, although it is slightly better supplied with these elements than the associated flatwoods type, Lufkin silt loam. The Caddo silt loam is generally considered a better type for general farming than the Lufkin silt loam, as the subsoil of the Caddo silt loam is usually not so impervious to water as that of the Lufkin soil.

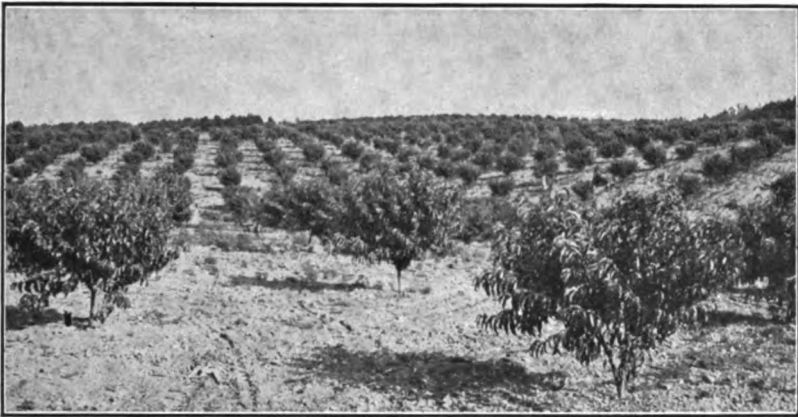
The Caddo silt loam as found in Hempstead County, where it is found in close proximity to some of the black lands, carries more total plant food than these average figures would indicate, and where the Caddo silt loam is found associated with other Caddo types, the Ruston and Norfolk soils, the content of these elements is even lower than this average would indicate. These flatwoods types will be some of the most difficult soils which we have to bring under a high state of cultivation. The fact that the Caddo silt loam carries so many of these low circular mounds makes leveling for irrigation for rice growing rather difficult, although the impervious subsoil would make retention of irrigation water possible.

#### GREENVILLE GRAVELLY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction               |
|----------------------------------|---------------------|--------|------------------------|
|                                  | Pounds              | Pounds |                        |
| In 2,000,000 pounds surface soil | 1400                | 360    | Slightly acid to acid. |
| In 2,000,000 pounds subsoil      | 1060                | 400    | Strongly acid.         |

The surface soil of the Greenville gravelly loam is a reddish brown fine sandy loam to clay loam, containing a large amount of rather small gravel, a large proportion of the gravel being found on the immediate surface. The Greenville gravelly loam passes at from 4 to 10 inches to a red, friable, gravelly clay loam to clay. The character of the gravel may vary decidedly, but as a rule highly ferruginous fragments make up a large portion of the gravel, although in other places the gravel may be largely quartz. As a general rule the nearer the Greenville gravelly loam is found to the foothills of the Ozarks the more quartz will be found in the gravel, and the farther the Greenville gravelly loam is found removed from the foothills the more iron containing gravel is found.

The topography of the Greenville gravelly loam is rolling to hilly, giving a good surface drainage. The open nature of the subsoil also helps to give this type good natural drainage, and



The Greenville gravelly loam is one of the strongest upland soils of South Arkansas. It occurs on undulating to rolling topography.

percolation of the water goes on rather rapidly through this subsoil. While this type is found on rather hilly topography, still the damage done by erosion is not nearly so great as it is on other types occupying the same topography. The open nature of the soil and the gravelly surface help to prevent serious damage from erosion. In spite of this fact, however, it would pay to terrace some of the more steeply sloping land.

The Greenville gravelly loam is not well supplied with either total nitrogen or phosphorus, and steps should be taken to increase the soil's content of both of these elements even though it is better supplied with these elements than most of the upland soils of the Coastal Plain section. In its natural state the Greenville gravelly loam is one of the more desirable soils of the Coastal Plain section, and because of its fine physical makeup responds readily to good treatment.

Farmers are recognizing the adaptability of Greenville gravelly loam to strawberries and other truck crops, while its adaptability to peach growing is evidenced by the good results obtained at the Highland orchard, a large part of the Highland peach orchard being located on the Greenville gravelly loam.

The Greenville gravelly loam is slightly acid to acid. Where crops are susceptible to acidity are to be grown, from one ton to a ton and a half of ground limestone per acre should be applied.

#### HOUSTON CLAY

|                                  | Nitrogen Phosphorus |        | Reaction         |
|----------------------------------|---------------------|--------|------------------|
|                                  | Pounds              | Pounds |                  |
| In 2,000,000 pounds surface soil | 2640                | 1230   | Neutral to acid. |
| In 2,000,000 pounds subsoil      | 1460                | 900    | Neutral to acid. |

The surface soil of the Houston clay consists of a brown to black clay loam or clay, which passes at from 6 to 10 inches into a light brown to yellowish brown clay, this material passing with depth into a greenish yellow to drab plastic clay. The substratum consists of a greenish yellow to light grey chalky clay, usually containing relatively large amounts of calcium carbonate or lime.

The Houston clay is the typical black prairie land of Southwest Arkansas, and is closely related to the black prairie land of Southeast Oklahoma and Northeast Texas. The type is gently undulating to rolling and except on the flatter areas the drainage is good. The soil is inclined to erode readily so that on the steeper slopes damage is caused by washing unless the soil is protected.

The Houston clay is fairly well supplied with both total nitrogen and phosphorus, being much better supplied with phosphorus than any other upland soil in the Coastal Plain area, and in fact in the state. This soil is the most productive upland soil in the section of the state in which it is found, and where erosion is not permitted the soil holds up well under continuous cropping.

One of the greatest difficulties in working this type is the difficulty of keeping it in good tilth. The soil is inclined to clod badly if plowed when the moisture content is not just right. This tendency to clod can be reduced by the turning under of organic matter.

There is considerable variation in the acidity or lime requirement of different areas of this soil. Although it is a soil which is derived from highly calcareous clay, still in many places the soil needs lime. Over much of the area, however, alfalfa will do well under natural conditions, and in the better drained areas this crop should receive wider attention than it is receiving at the present time.

#### OKTIBBEHA VERY FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        |                     |
|----------------------------------|---------------------|--------|---------------------|
|                                  | Pounds              | Pounds | Reaction            |
| In 2,000,000 pounds surface soil | 1080                | 260    | Slightly acid.      |
| In 2,000,000 pounds subsoil      | 900                 | 220    | Very strongly acid. |

The surface soil of the Oktibbeha very fine sandy loam is a light brownish gray to reddish gray very fine sandy loam, with a depth of from 10 to 12 inches. This surface material passes rather quickly into a yellowish brown to yellowish red clay, which with increasing depth becomes a dull yellowish red plastic clay with gray mottling. The substratum consists of calcareous material resulting from the weathering of the underlying chalk beds. This material may be found at depths varying from 3 to 12 feet below the surface of the ground. On gently rolling

topography where erosion has been active, this calcareous material will be found at the shallower depths.

The Oktibbeha very fine sandy loam is found only in the black prairie belt in Southwest Arkansas, associated with the Houston and Sumter soils. It is usually found capping the higher hills in the black prairie sections, the Sumter clay or "lime hills" usually occupying the steeper slope. The type as a whole is fairly well drained, although the leveler lying portions occasionally need some artificial drainage, as the heavy clay subsoil is rather impervious to water, making movement of water down through the subsoil very slow.

The type is not very well supplied with either nitrogen or phosphorus, and in building up this soil attention should be paid to both of these elements.

The turning under of green manure crops, especially legumes, should become a common practice on this type of soil. Acid phosphate used at the rate of 200 to 250 pounds per acre may be used in connection with legume crops. A fertilizer analyzing approximately 9-3-2, used at the rate of 400 pounds per acre, will give good results with cotton.

The reaction of this soil is slightly acid. The use of ground limestone at the rate of one ton per acre will likely give a good return on the money invested on the more acid portions of this type, where legumes sensitive to acidity are grown.

Throughout the regions where the Oktibbeha very fine sandy loam is found there are occasional small areas of Oktibbeha clay. The Oktibbeha clay has much the same characteristics as the Oktibbeha very fine sandy loam, except that there is more clay found in the surface soil.

It is a question whether as large returns can be expected from acid phosphate on the Oktibbeha clay as on the very fine sandy loam, as we find more of the Houston material mixed in the clay. The Houston material generally carries a fairly good supply of phosphorus.

#### LUFKIN SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction            |
|----------------------------------|---------------------|--------|---------------------|
|                                  | Pounds              | Pounds |                     |
| In 2,000,000 pounds surface soil | 1380                | 260    | Strongly acid.      |
| In 2,000,000 pounds subsoil      | 580                 | 150    | Very strongly acid. |

The surface soil of the Lufkin silt loam is a light gray to gray compact silt loam, which passes rather quickly into a light gray or almost white still more compact silt loam, or silty clay. The lower subsoil may become even more compact, and is frequently mottled with yellow and pale red.

The Lufkin silt loam is a typical flatwoods type. Its level topography coupled with the impervious nature of the soil makes it a rather refractory soil. Water stands on the flatter areas

for long periods. Artificial drainage is necessary before general farm crops can be profitably grown on much of this type. In certain sections, however, rice is grown profitably as the impervious nature of the soil makes flooding of the land easily accomplished.

This soil is not well supplied with nitrogen and is very poorly supplied with total phosphorus. Where rice is grown on this type the use of acid phosphate will be highly desirable, although for normal crops the land must be drained before fertilizers can be profitably used.

Where some of the better drained areas have been brought under cultivation and steps have been taken to increase the nitrogen and phosphorus supply of the soil, the use of ground limestone will prove beneficial.

#### NORFOLK SAND

|                                  | Nitrogen Phosphorus |        | Reaction |
|----------------------------------|---------------------|--------|----------|
|                                  | Pounds              | Pounds |          |
| In 2,000,000 pounds surface soil | 320                 | 480    | Acid.    |
| In 2,000,000 pounds subsoil      | 260                 | 280    | Acid.    |

The Norfolk sand is a light gray to almost white loose sand, which passes at from 5 to 8 inches into a yellowish gray or pale yellow loamy sand. This material may continue with little change throughout the 3-foot section, although usually the material passes into a sandy loam or even a friable sandy clay in the lower subsoil.

This soil is usually found occupying rather high, gently rolling hills, and drainage is well developed. Because of the open character of both surface and subsoil drainage is rather complete, and crops can not withstand long and continued dry weather. This type, however, warms up rapidly in the spring and is very well adapted to early truck, a type of farming which should be carried on more extensively where this and the associated type, Norfolk fine sand, are found in large bodies.

This type is one of the poorest soils from the standpoint of content of plant food, to be found in the state. The organic matter and nitrogen content are almost negligible. There is approximately as much nitrogen in a ton of nitrate of soda as there is in a thousand tons of surface soil of an acre.

At first thought one might think that the profitable cultivation of this type and of the Norfolk fine sand, which is only slightly better supplied with plant food, would be a hopeless task. Such is not the case. The type, even though occupying rather rolling hills, does not suffer greatly from erosion. Its open nature permits it to warm up rapidly, and the addition of organic matter will greatly aid in increasing the moisture holding capacity of the soil. By keeping a crop growing on the soil as much

of the year as possible to prevent loss from leaching, turning under organic matter and using a complete fertilizer, the soil will prove to be a profitable one to use for early truck.

#### NORFOLK FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction       |
|----------------------------------|---------------------|--------|----------------|
|                                  | Pounds              | Pounds |                |
| In 2,000,000 pounds surface soil | 620                 | 200    | Strongly acid. |
| In 2,000,000 pounds subsoil      | 320                 | 160    | Strongly acid. |

The surface soil of the Norfolk fine sandy loam consists of a light gray or yellowish gray fine sand to fine sandy loam, which passes at from 5 to 8 inches into a pale yellow fine sandy loam. This material grades with depth into a heavy fine sandy loam or friable fine sandy clay, yellow in color.

The topography varies from almost level to gently rolling. Most of the type has fairly good drainage, although the lower-lying, flatter areas are sometimes only poorly drained. This type is more retentive of moisture than the coarser textured soils of the same series, and is much better adapted to general farming than these coarser textured types.

This soil is not well supplied with either total nitrogen or phosphorus, and the increase of these plant foods is essential. Owing to its good physical condition this soil responds readily to good treatment. In building up this soil it will be well, for the time being at least, to use a complete fertilizer on the money crops, at the same time building up the organic matter content as quickly as possible.

#### ORANGEBURG FINE SANDY LOAM

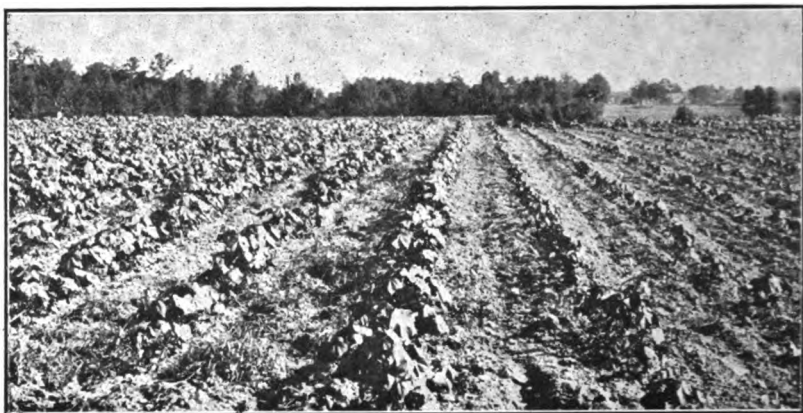
|                                  | Nitrogen Phosphorus |        | Reaction                        |
|----------------------------------|---------------------|--------|---------------------------------|
|                                  | Pounds              | Pounds |                                 |
| In 2,000,000 pounds surface soil | 940                 | 220    | Slightly acid to strongly acid. |
| In 2,000,000 pounds subsoil      | 720                 | 200    | Acid to strongly acid.          |

The Orangeburg fine sandy loam is light brownish gray to gray fine sandy loam to fine sand, which passes at about 8 to 10 inches into a red, friable sandy clay, usually continuing to become heavier with depth, although in many places this sandy clay continues down through three feet or more in depth. On some of the steeper hillsides where erosion has been active frequently the surface soil is inclined to be heavy, due to the fact that the subsoil has been worked up into the surface soil through plowing. On these points the immediate surface is inclined to have a reddish cast.

From a physical standpoint the subsoil of the Orangeburg fine sandy loam is one of the best to be found in the Coastal



**Plain region.** The soil is open and permits the percolation of water, and at the same time it contains sufficient clay and other fine material to be capable of holding a good supply of moisture.



The higher lying lands composed of the Ruston, Susquehanna, and Orangeburg soils are the first soils to be cleared and cultivated. Cotton is the principal crop grown.

The type is not very extensively developed in most parts of Arkansas, but where found usually caps the higher hills. A considerable portion of the type occupies rather steeply sloping hillsides. The type as a whole is well drained; in fact over much of the type drainage is excessive and the land should be terraced before cultivating.

This soil is not well supplied with either nitrogen or phosphorus; in fact it is very low in total phosphorus. Because of its good physical condition, however, this soil responds readily to good soil management.

The organic matter content of this soil is very low, and all practical means should be adopted for incorporating organic matter into this soil. Most of this organic matter should come from legumes. By turning under a legume crop it is possible to increase the nitrogen content of the soil, which must be increased before crops will give best results. Although we should depend mainly on gathering nitrogen from the air by the growing of legume crops, still in building up this land it will be well to use some nitrogen in the fertilizer, especially where cotton or corn are to be grown. In the fertilization of a legume a fertilizer analyzing approximately 11-0-2, used at the rate of 250 pounds per acre, will give good results. For cotton a fertilizer analyzing approximately 9-3-3, used at the rate of 300 to 400 pounds per acre, is recommended.

For the present it will be well to use funds available for

soil improvement in the purchase of highly phosphatic fertilizers rather than the purchase of lime for correcting the acidity of this soil, in spite of the fact that the soil is in many places decidedly acid. The farmers of the Coastal Plain section are fortunate in being able to use a number of legumes which will give profitable yields on acid soils, and these legumes should be used. As the nitrogen and phosphorus supply in this soil is increased the use of lime will be desirable.

#### RUSTON FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction               |
|----------------------------------|---------------------|--------|------------------------|
|                                  | Pounds              | Pounds |                        |
| In 2,000,000 pounds surface soil | 940                 | 280    | Slightly acid to acid. |
| In 2,000,000 pounds subsoil      | 740                 | 240    | Very strongly acid.    |

The surface soil of the Ruston fine sandy loam is a yellow gray to brownish gray loamy fine sand or fine sandy loam, which passes at from 5 to 8 inches into a yellow or reddish yellow fine sandy loam containing considerably more clayey material. At from 12 to 16 inches this material passes into a reddish yellow to yellowish red fine sandy clay, which frequently becomes much heavier and mottled with yellow and gray in the lower subsoil. While in many places the subsoil becomes quite heavy, still it never becomes as tough and impervious to water as the subsoil of the Sesquehanna soils. Neither is the subsoil of the Ruston



The better drained soils of the Coastal Plain respond readily to the use of fertilizers. No fertilizer applied in center. Nitrogen and phosphorus on the right and a complete fertilizer on the left.

soil as open and of such desirable texture as the Greenville or Orangeburg soils.

Small areas of the Ruston fine sandy loam are found throughout the Coastal Plain area. The soil is usually found capping, or on the upper portions of the hills. As a general rule this type is well drained. On some of the steeper slopes the run-off is so rapid that erosion takes place. However, as the soil is open and porous there is not as much damage due to surface washing on this type as on some of the finer textured soils.

This soil is not well supplied with either total nitrogen or phosphorus, being very low in total phosphorus. Fertilizers used on this type should carry a high per cent of phosphoric acid, and farming operations should turn toward increasing the nitrogen supply of the soil. The nitrogen can be added more economically through the growing of legume crops, but for the present at least it will be well to use a complete fertilizer on cotton. A fertilizer analyzing 9-3-3, used at the rate of 400 pounds per acre, where the soil is in fair condition for holding moisture will give profitable returns.

The soil is slightly acid to acid, but for the present at least it will be better to depend on crops which are not very susceptible to acidity, and use any funds available for soil building in the purchase of phosphatic fertilizers rather than to spend the money on ground limestone.



Farmers recognize the great difference between the better drained more fertile Ruston soils and the cold natured Caddo soils, using the Caddo soils for pasture while cultivating the Ruston soils.

## RUSTON VERY FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction               |
|----------------------------------|---------------------|--------|------------------------|
|                                  | Pounds              | Pounds |                        |
| In 2,000,000 pounds surface soil | 1040                | 300    | Acid to strongly acid. |
| In 2,000,000 pounds subsoil      | 860                 | 240    | Very strongly acid.    |

The surface soil of the Ruston very fine sandy loam consists of a yellowish gray to grayish brown very fine sandy loam, which passes at from 5 to 8 inches into a reddish yellow or dull red, heavy, very fine sandy loam or clay loam. This material is underlaid at from 15 to 20 inches by a friable yellowish red sandy clay. The lower subsoil frequently becomes lighter colored, and mottlings of yellow and gray and bright red are common.

The type is undulating to gently rolling. In the more level and lower lying areas low mounds are found. On the whole the drainage is good.

The total supply of both nitrogen and phosphorus in this soil is low, the soil containing only slightly more nitrogen than the Ruston fine sandy loam, and practically the same amount of phosphorus. The treatment of this soil should be the same as that suggested for the Ruston fine sandy loam.

## SUMTER CLAY

|                                  | Nitrogen Phosphorus |        | Reaction             |
|----------------------------------|---------------------|--------|----------------------|
|                                  | Pounds              | Pounds |                      |
| In 2,000,000 pounds surface soil | 2140                | 500    | Alkaline to neutral. |
| In 2,000,000 pounds subsoil      | 1660                | 700    | Alkaline.            |

The surface soil of the Sumter clay is a grayish brown, olive drab or greenish brown clay, which usually passes at from 6 to 8 inches into a pale yellow calcareous clay. There is a distinct greenish cast to both the surface soil and the upper subsoil; in fact this unusual greenish color is characteristic of the type. The Sumter clay rests on a hard calcareous clay or chalk marl, which represents the parent rock of this soil.

This soil is found in this state only in the Black Land area in the southwestern portion of the state. The topography is generally gently rolling to hilly, and the drainage is almost always good. Erosion is serious over much of the type, due to the combination of rolling topography with the close natured soil. In places erosion has been so serious that the surface soil has been completely removed over areas large enough to map the underlying chalk. These areas where the surface soil has been removed are sometimes referred to as "lime hills".

This soil is much better supplied with both nitrogen and phosphorus than most of the Coastal Plain soils. The soil is also well supplied with lime. The first step to take in the improvement of this type is to check erosion as far as possible. Prob-

ably one of the best means of accomplishing this result is to turn the land into grass. The Sumter clay originally was prairie land and supported only a scattering growth of trees. The type should afford excellent pasturage where care is taken in getting the grass established. Even alfalfa may be grown successfully on this soil under natural conditions.

#### SUSQUEHANNA FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        |                        |
|----------------------------------|---------------------|--------|------------------------|
|                                  | Pounds              | Pounds | Reaction               |
| In 2,000,000 pounds surface soil | 800                 | 200    | Acid to strongly acid. |
| In 2,000,000 pounds subsoil      | 720                 | 240    | Very strongly acid.    |

The typical surface soil of the Susquehanna fine sandy loam is a light brownish gray to gray fine sandy loam, which passes at from 6 to 8 inches into a yellowish red fine sandy loam, this passing quickly at from 10 to 15 inches into a stiff, red clay. This heavy clay becomes mottled with yellow and gray as depth increases. In some local areas where drainage is not well developed there is less red in the subsoil and more yellow and gray, especially gray.

On the whole the type has good surface drainage, most of the type occupying gently rolling to rolling topography. As with other types occupying steeply sloping hillsides, terracing is of first importance.

This soil is very low in both total nitrogen and phosphorus, especially low in phosphorus. The same treatment suggested for the Sesquehanna very fine sandy loam would apply to the Sesquehanna fine sandy loam. The necessity of adopting these suggestions is even more apparent on the Susquehanna fine sandy loam than on the finer textured soil.



The Susquehanna soils vary from gently undulating to hilly. These soils have stiff clay subsoils. Cotton does better on these soils than on some of the soils with lighter textured subsoils.

A soil such as this gives fairly good yields the first few years after brought under cultivation, but due to the low total supply of plant food present it runs down rapidly under cultivation. Where new lands of this type are brought under cultivation it would be well to adopt fertilization from the very beginning, as it is much easier to maintain lands than it is to build them up after they have once run down.

#### SUSQUEHANNA VERY FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction               |
|----------------------------------|---------------------|--------|------------------------|
|                                  | Pounds              | Pounds |                        |
| In 2,000,000 pounds surface soil | 1240                | 340    | Acid to strongly acid. |
| In 2,000,000 pounds subsoil      | 1000                | 340    | Very strongly acid.    |

The surface soil of the Susquehanna very fine sandy loam is a light gray or yellowish gray very fine sandy loam, which passes at from 4 to 6 inches to a yellowish or yellowish red very fine sandy loam. At from 10 to 16 inches a stiff plastic clay is encountered. This tough red clay is usually mottled with gray and some yellow, the mottling increasing with depth.

The Susquehanna very fine sandy loam is rather widely distributed throughout the Coastal Plain section of the state. It usually occupies gently rolling to rolling topography, although occasionally it occupies only gently sloping hillsides. Where the topography is only gently rolling we usually find an approach toward the silt loam.

The type as a whole has good surface drainage, although the tight subsoil makes percolation of water downward through the subsoil slow. The fact that the subsoil does not permit ready movement of water downward results in rather serious erosion where the soil occupies steeply sloping land. Land of this character where clean cultivation is practiced should be terraced.

The Susquehanna very fine sandy loam is not very well supplied with nitrogen, and is very low in total phosphorus present. The supply of organic matter is also deficient. As with the other members of the Susquehanna series the incorporation of organic matter is of great importance. Since the soil contains so little phosphorus it will be slow work increasing the organic matter content of the soil unless some phosphorus is added to increase the growth of crops on the soil. The addition of highly phosphatic fertilizers, together with the turning under of legume crops, will be the surest method of building up this soil.

While increasing the soil's nitrogen supply by turning under legume crops it will be well to use a complete fertilizer on the cash crops, especially cotton. A fertilizer analyzing approximately 9-3-3, used at the rate of 300 or 400 pounds per acre, is recommended. On soils where attention has been paid to keeping up the organic matter supply and where good cultural

methods are used, the larger amount may well be used, while on soils where the organic matter supply has become depleted and only fair preparation of the seed bed has been made, the smaller application would be more profitable.

Since the soil is acid it will be desirable to plan on rotations which contain legume crops which are not highly susceptible to soil acidity. Legumes such as cow peas, bur clover, and velvet beans, are not injured as seriously by soil acidity as most of the legumes, and these or similar crops should be used. For the present it will likely prove to be more profitable to purchase phosphorus carrying fertilizers than to use the money in buying lime to correct the acidity of the soil.

After the nitrogen and phosphorus supply is built up to a fair level, the use of lime should be considered.

#### SUSQUEHANNA SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                        |
|----------------------------------|---------------------|--------|---------------------------------|
|                                  | Pounds              | Pounds |                                 |
| In 2,000,000 pounds surface soil | 1780                | 500    | Slightly acid to strongly acid. |
| In 2,000,000 pounds subsoil      | 1140                | 480    | Very strongly acid.             |

The Susquehanna silt loam is a light brownish gray to gray incoherent silt loam, which passes at from 4 to 16 inches into a yellow or yellowish red silty clay loam, this material at from 12 to 20 inches changing into a red or a yellowish red and gray mottled plastic clay.

The topography of the Susquehanna silt loam is quite variable. In many places the type occupies flat areas, these areas being poorly drained. The heavy clay subsoil found under the Susquehanna silt loam is almost impervious to water, so that where the type lies on flat topography the natural drainage is very deficient, quite the extreme of this condition prevails in some places where the type occupies rolling to steep hillsides, and under these conditions drainage is excessive and much damage is done by erosion. In many cultivated fields where the Susquehanna silt loam is found on these hillsides the surface soil has been washed off, leaving the heavy clay naturally found at a lower depth exposed on the surface. The drainage of these flatter lying areas and terracing of the more rolling lands should be given first consideration.

While the Susquehanna silt loam contains more plant food than most of the upland soils of the Coastal Plain section of the state, still it is not well stocked with nitrogen and phosphorus. A permanent system of farming on this type should include the addition of these elements to the soil, and this should follow immediately after erosion has been taken care of through ter-

racing and better plowing on the hillsides and the excess water has been removed on the flatter areas.

Green manure crops, such as rye, bur clover, and cowpeas should be given a large place. The nitrogen can be supplied to this soil most economically through turning under legume crops, but the phosphorus must be purchased. Although eventually the farmer may hope to maintain the nitrogen content of this soil through turning under legumes, still for the present it would be well to include some nitrogen in the fertilizer used, at least on crops such as cotton and corn, unless a green manure crop is being turned under for these crops, in which case acid phosphate alone at the rate of 250 pounds per acre may be used.

Acid phosphate used alone in connection with legumes gives a good return. In preparing ground for corn a good procedure would be to fertilize a legume, such as cowpeas, with acid phosphate, the legume being turned under for the corn. The increased growth of the legume due to the application of acid phosphate, will give a large return in the corn produced.

The surface soil of the Susquehanna silt loam is slightly acid to strongly acid, while the subsoil is very strongly acid. The use of ground limestone at the rate of a ton per acre is recommended on this type, where crops are grown in the rotation that are highly susceptible to acidity.

#### SUSQUEHANNA CLAY

|                                  | Nitrogen Phosphorus |        | Reaction               |
|----------------------------------|---------------------|--------|------------------------|
|                                  | Pounds              | Pounds |                        |
| In 2,000,000 pounds surface soil | 1120                | 340    | Slightly acid to acid. |
| In 2,000,000 pounds subsoil      | 1020                | 280    | Very strongly acid.    |

The surface soil of the Susquehanna clay is usually very shallow, consisting of from 2 to 5 inches of light brownish gray to yellowish gray material, which varies from a very fine sandy loam to a clay loam.

This material passes rather quickly to a stiff red clay, which becomes tougher and more tenacious with depth, at the same time becoming mottled with yellow and gray.

Most of the type is rolling to hilly, although where found associated with the Houston clay in the southwestern part of the state, many rather flat areas are found. Here the soil takes on a darker color in the surface, and more yellow and drab and less red are found in the subsoil. With the exception of these flatter areas the type is well drained. In fact the surface run-off is doing great damage on much of this type. Small areas of the Susquehanna clay are developing in the hilly section of the state where the surface soil is being removed from the other soils of the Susquehanna series, this leaving the heavy clay subsoil nearer or even at the surface.



The Susquehanna clay is not well supplied with either nitrogen or phosphorus. The increase of both of these elements is of vital importance. The Susquehanna clay found associated with the Houston clay in Southwest Arkansas is somewhat better supplied with total phosphorus than the average of the type, although even here it will be well to include some phosphorus in the fertilizer.

Susquehanna clay is slightly acid to acid. Where crops readily affected by acidity are grown in the rotation it will be well to use some lime. For the present, however, it will likely prove more profitable to depend on legumes which are not extremely susceptible to soil acidity, and purchase highly phosphatic fertilizers rather than buy limestone, especially where the funds are limited.

### Terrace and Bottom Lands

#### Hill Section

#### ATKINS SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                    |
|----------------------------------|---------------------|--------|-----------------------------|
|                                  | Pounds              | Pounds |                             |
| In 2,000,000 pounds surface soil | 2580                | 320    | Acid to very strongly acid. |
| In 2,000,000 pounds subsoil      | 1580                | 520    | Very strongly acid.         |

The Atkins silt loam consists of a light brownish gray to gray silt loam or silty clay loam, which quickly passes into a compact yellowish gray or bluish gray silty clay loam or silty clay. In the deeper subsoil gray and drab colors predominate with mottlings of pale yellow and rusty brown. This lower subsoil is a tenacious clay, almost impervious to water.

The Atkins silt loam is found associated with the Pope silt loam, being a first bottom soil occupying the low, flat areas. The dense subsoil coupled with the low elevation of the type makes this soil very poorly drained. Most of the type is still covered with willow oak, water oak, and sweet gum.

The type is fairly well supplied with nitrogen but carries a relatively low amount of phosphorus. This soil contains more of these elements than the more highly productive Pope silt loam. The low yields obtained on this type must be attributed to the poor physical condition.

Improvement of drainage is of first consideration on most of the Atkins silt loam, and with thorough drainage much better yields than are commonly obtained may be expected. Where proper drainage has been established, phosphorus carrying materials may be profitably used where the nitrogen and organic matter content is being maintained.

The soil is acid to very strongly acid, and where the land has been drained one to two tons of ground limestone per acre may be used with profit, where legumes sensitive to soil acidity are to be grown.

#### HUNTINGTON LOAM

|                                  | Nitrogen Phosphorus |        |                  |
|----------------------------------|---------------------|--------|------------------|
|                                  | Pounds              | Pounds | Reaction         |
| In 2,000,000 pounds surface soil | 3200                | 680    | Neutral to acid. |
| In 2,000,000 pounds subsoil      | 2020                | 730    | Neutral to acid. |

The Huntington loam varies from a brown fine sandy loam to a brown silt loam, depending upon the relative amount of wash received from sandy and silty soils. The subsoil may be little different from the surface. Usually, however, the subsoil is a lighter brown.

The soil is a typical creek bottom soil, and most of it is overflowed during high water. As a rule the water does not stand on it for long periods and on the whole the type is fairly well drained. There are areas where drainage will pay. The type is flat to gently undulating, although some areas are badly cut up by old stream channels.

The Huntington loam is one of the strongest and most highly prized soils in the limestone section where it occurs. It is well supplied with total nitrogen, but care should be exercised to maintain the supply. The phosphorus content may well be increased where the land has been under cultivation for some time.

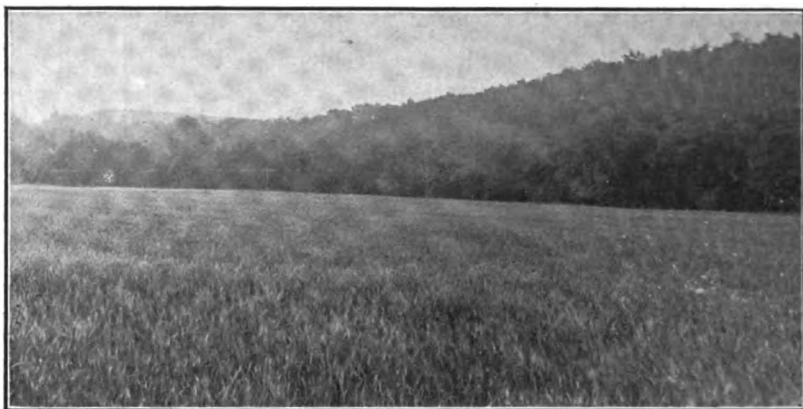
While most of the type is well supplied with lime, some areas are acid. Alfalfa will do well on most of the better drained land without the use of lime, although lime can be profitably used where alfalfa is to be grown where the soil is acid.

#### POPE SILT LOAM

|                                  | Nitrogen Phosphorus |        |                  |
|----------------------------------|---------------------|--------|------------------|
|                                  | Pounds              | Pounds | Reaction         |
| In 2,000,000 pounds surface soil | 2380                | 760    | Neutral to acid. |
| In 2,000,000 pounds subsoil      | 1660                | 740    | Neutral to acid. |

The surface soil of the Pope silt loam is a mellow, brown silt loam. The subsoil is a yellowish brown heavy silt loam or silty clay loam, frequently with a noticeable reddish cast. In depressed areas where the drainage is poorly developed gray mottling may occur in the lower subsoil.

The Pope silt loam is a typical first bottom soil occurring along creeks and small streams throughout the hill regions where the soils are derived from sandstone and shale. Most of the type is fairly well drained as indicated by the reddish or yellowish brown subsoil.



The Pope silt loam is a valuable creek bottom soil found in the sandstone and shale country.

The surface of the Pope silt loam is generally level, although it is occasionally cut up by old stream beds, so that improved farming implements may be used to good advantage on the larger areas. The mellow character of the soil makes the soil easily handled, so that altogether the soil is one of the most highly prized soils of the area in which it occurs.

The soil is fairly well supplied with nitrogen and organic matter. It is noticeably low in its content of phosphorus. By maintaining the organic matter content in the newly cleared areas and increasing it in the older, worn soils, and by using phosphorus carrying fertilizers, the fertility of this soil may be maintained. As cultivation is continued it will become necessary to use some lime in order to obtain best results, but the use of lime is not advised at present unless the particular area is known to be acid.

#### WAYNESBORO LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                    |
|----------------------------------|---------------------|--------|-----------------------------|
|                                  | Pounds              | Pounds |                             |
| In 2,000,000 pounds surface soil | 1380                | 600    | Very slightly acid to acid. |
| In 2,000,000 pounds subsoil      | 860                 | 380    | Acid.                       |

The surface soil of the Waynesboro loam is a reddish brown to brown friable loam, usually 6 to 10 inches deep. This material is underlaid by a sandy clay or clay of reddish color. In the lower lying areas this reddish clay may give way to a yellowish material sometimes mottled with gray.

The Waynesboro loam is a terrace type, at least most of the

material having been deposited by stream action in years past. Many times, however, it is found difficult to draw a line between the Hanceville loam, which is a strictly upland type, and the Waynesboro loam, although the Waynesboro loam lies at lower elevation and is usually more gently undulating than the Hanceville loam. The Waynesboro loam is more highly prized by the farmers than the Hanceville loam.

The Waynesboro loam is not well supplied with either nitrogen or phosphorus, and in building up this type attention should be paid to both these elements. The growing of legumes and turning at least a portion of them into the soil, and deeper plowing, should be adopted. The use of acid phosphate at the rate of 200 to 250 pounds per acre should be used in connection with the increase of the nitrogen content of this soil.

The surface soil of the Waynesboro loam is very slightly acid to acid, and the use of ground limestone at the rate of a ton per acre is recommended.

### Coastal Plain Section

#### BIBB VERY FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        |                                      |
|----------------------------------|---------------------|--------|--------------------------------------|
|                                  | Pounds              | Pounds | Reaction                             |
| In 2,000,000 pounds surface soil | 1400                | 480    | Acid to strongly acid.               |
| In 2,000,000 pounds subsoil      | 1060                | 440    | Strongly acid to very strongly acid. |

The Bibb very fine sandy loam consists of a light gray somewhat compact very fine sandy loam, which passes at from 6 to 8 inches into a mottled gray and yellow fine sandy loam or silt loam, this material passing at from 16 to 20 inches into a rather compact silt loam or fine sandy clay, mottled with gray and yellow. Iron concretions are rather common, especially in the lower subsoil.

This type, as well as the associated Bibb silt loam, occupies wide, flat, poorly drained first bottom land in the Coastal Plain section. Natural drainage being poor, very little of this type is at present under cultivation. Artificial drainage will be required before profitable returns can be obtained on this soil.

This soil is rather poorly supplied with both total nitrogen and phosphorus. In its present wet condition, even though cleared, the use of commercial fertilizers on this soil would be a questionable procedure. The type, however, is suited to pasturing even under the present condition.

**HANNAHATCHEE FINE SANDY LOAM**

|                                  | Nitrogen Phosphorus |        | Reaction |
|----------------------------------|---------------------|--------|----------|
|                                  | Pounds              | Pounds |          |
| In 2,000,000 pounds surface soil | 2080                | 1060   | Acid.    |
| In 2,000,000 pounds subsoil      | 1980                | 940    | Acid.    |

The Hannahatchee fine sandy loam is a light brown to red-dish brown fine sandy loam, which passes at various depths into a red or yellowish red friable sandy clay. The change from the surface soil into the subsoil is usually rather gradual.

The type occurs as first bottom land along small streams in the southwestern portion of the state. The type occurs on practically level topography, yet because of its open structure it is naturally well drained. Although only fairly well supplied with total nitrogen and phosphorus, still this soil is one of the most desired soils to be found in the Coastal Plain section. The soil is easily handled and is very responsive to fertilization where the soil has been under cultivation for some time and the most available plant food material has been found.

**OCHLOCKONEE SILT LOAM**

|                                  | Nitrogen Phosphorus |        | Reaction       |
|----------------------------------|---------------------|--------|----------------|
|                                  | Pounds              | Pounds |                |
| In 2,000,000 pounds surface soil | 2200                | 480    | Strongly acid. |
| In 2,000,000 pounds subsoil      | 1640                | 240    | Strongly acid. |

The Ochlockonee silt loam is a grayish brown to brownish gray silt loam, which passes rather quickly into light brownish gray to gray, rather compact silt loam, with rusty brown or gray mottlings. This soil is found as a first bottom land type in the Coastal Plain area. The surface is generally flat, although there are old sloughs and ditch-like channels running through the bottom land. As a general rule the drainage is poor, although the drainage is better on the Ochlockonee silt loam than it is on the somewhat lower, flatter lying Bibb soil.

The Ochlockonee silt loam is better supplied with nitrogen than the upland soils in this section of the state, but its supply of phosphorus is only meager. Where this soil is artificially drained good crops can be expected for several years. The use of highly phosphatic fertilizers is to be recommended on this soil.

**OCHLOCKONEE CLAY**

|                                  | Nitrogen Phosphorus |        | Reaction       |
|----------------------------------|---------------------|--------|----------------|
|                                  | Pounds              | Pounds |                |
| In 2,000,000 pounds surface soil | 2660                | 600    | Acid.          |
| In 2,000,000 pounds subsoil      | 1480                | 640    | Strongly acid. |

The Ochlockonee clay consists of a grayish brown to brown

silty clay or clay loam, which passes at from 6 to 10 inches into a brownish gray clay loam or clay, this passing into a gray or drab clay. The Ochlockonee clay is a first bottom land soil occurring in the Coastal Plain region. As a general rule it occurs at slightly lower elevations than the Ochlockonee silt loam, and is even more poorly drained than the silt loam. Artificial drainage is necessary before cultivation can be made profitable.

This soil is fairly well supplied with total nitrogen but rather poorly supplied with total phosphorus. Following thorough drainage of this type, the use of acid phosphate will very likely give most profitable results.

Although this soil is acid, the use of limestone on this type is not recommended until after thorough drainage and liberal applications of phosphatic fertilizers have been made.

#### TRINITY CLAY

|                                  | Nitrogen Phosphorus |        | Reaction             |
|----------------------------------|---------------------|--------|----------------------|
|                                  | Pounds              | Pounds |                      |
| In 2,000,000 pounds surface soil | 4080                | 1520   | Alkaline to neutral. |
| In 2,000,000 pounds subsoil      | 2700                | 920    | Alkaline to neutral. |

The Trinity clay is a dark brown to black calcareous clay, this material usually continuing with little change throughout the 3-foot section, although lighter colored material is frequently found in the subsoil.

The Trinity clay is found in the bottom land receiving wash from the Houston clay and associated types. As a general rule the drainage is rather poor, yet because of its high productive powers most of the type has already been drained artificially.

The soil is well supplied with both total nitrogen and phosphorus. It is one of the strongest soils in the state. As with the Houston clay, the chief difficulty with this type is the tendency to clod if the land is worked when too wet or too dry. This type is better supplied with organic matter and contains more lime than the Houston clay, and there is less difficulty in preparing a good seed bed on this type than on the Houston clay.

This type is not acid and alfalfa does well on the better drained areas. Thorough drainage is essential for most profitable farming on this type.

#### CAHABA FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                  |
|----------------------------------|---------------------|--------|---------------------------|
|                                  | Pounds              | Pounds |                           |
| In 2,000,000 pounds surface soil | 1060                | 280    | Neutral to slightly acid. |
| In 2,000,000 pounds subsoil      | 880                 | 340    | Slightly acid to acid.    |

The Cahaba fine sandy loam consists of a dark gray to light brown fine sandy loam, which passes at from 6 to 8 inches into

a yellowish red fine sandy loam, this material passing into a yellowish red or dull red friable sandy clay.

The type occurs as second bottom land along the smaller streams in the Coastal Plain region. The type is inclined to be flat, yet even under natural conditions it has very good drainage due to the open nature of the soil and subsoil. This type is much better drained than the Kalmia fine sandy loam, which also occurs as a second bottom land soil in the same section of the state.

The soil is not well supplied with either total phosphorus or nitrogen, yet for a few years after being brought under cultivation gives very good yields. Due to its fine physical condition the soil responds readily to the use of commercial fertilizers.

#### LEAF SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction            |
|----------------------------------|---------------------|--------|---------------------|
|                                  | Pounds              | Pounds |                     |
| In 2,000,000 pounds surface soil | 1800                | 260    | Slightly acid.      |
| In 2,000,000 pounds subsoil      | 640                 | 180    | Very strongly acid. |

The Leaf silt loam is a dark gray to brown silt loam, which passes at from 6 to 10 inches into a reddish yellow or yellowish red clay, this material passing with depth into a red plastic clay mottled with gray and yellow. This type occurs as second bottom land and occupies very gently undulating or almost level topography. Due to the combination of level topography with the almost impervious subsoil, this soil has very poor natural drainage.

The soil is not well supplied with either total nitrogen or phosphorus, and the addition of both these elements is suggested. Deep plowing and the incorporation of organic matter into the soil, together with thorough drainage, will help to improve the physical condition of this type.

### Mississippi and White River Bottoms

#### First Bottom

#### SARPY VERY FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction |
|----------------------------------|---------------------|--------|----------|
|                                  | Pounds              | Pounds |          |
| In 2,000,000 pounds surface soil | 2000                | 1460   | Neutral. |
| In 2,000,000 pounds subsoil      | 1380                | 1400   | Neutral. |

The surface soil of the Sarpy very fine sandy loam is a brownish gray to brown fine sandy loam to very fine sandy loam 10 to 12 inches in depth. The subsoil usually consists of a lighter brown fine sandy loam or loamy fine sand, although occasionally clay makes up a considerable portion of the lower subsoil.

The type occupies relatively high lying areas along the Mississippi River, the Sarpy very fine loam and the closely associated Sarpy fine sandy loam making up the major portion of the higher lying lands along the river front. The type, although subject to overflow, has good natural under-drainage, due to its somewhat elevated position and the open character of the subsoil.

While not as well supplied with total nitrogen as some of the other types found in the same localities, the Sarpy fine sandy loam and very fine sandy loam are highly prized. They are easily handled, quick to warm up in the spring, and produce good crops. The maintenance and increase of the organic matter and nitrogen content through the growing and turning under of legumes is important.

#### SARPY SILTY CLAY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                       |
|----------------------------------|---------------------|--------|--------------------------------|
|                                  | Pounds              | Pounds |                                |
| In 2,000,000 pounds surface soil | 2760                | 1480   | Neutral to acid.               |
| In 2,000,000 pounds subsoil      | 1760                | 1200   | Neutral to very strongly acid. |

The surface soil of the Sarpy silty clay loam is a grayish to brown silt loam to silty clay, mottled with drab and gray. The subsoil is of coarser texture but rather variable in nature. Most commonly it is a yellowish brown very fine sandy loam, although it may be a rather coarse sand or alternating layers of sandy and silty material.

The type occurs as first bottom land in the Mississippi lowlands. Large areas are flat, while in other localities the type occupies low ridges. These ridges frequently represent old sand bars that during later overflows have received a deposit of finer material. Sand blows are frequently found on this type.

While not as strong a soil as the Sharkey clay, the Sarpy silty clay loam is a productive soil. It is fairly well supplied with both total nitrogen and phosphorus.

The reaction of this soil varies considerably. Most of the type, however, is neutral to very slightly acid.

Over a large portion of the type natural drainage is poor. Thorough drainage demands attention and is the first step to take in the improvement of this type.

#### SHARKEY CLAY

|                                  | Nitrogen Phosphorus |        | Reaction                   |
|----------------------------------|---------------------|--------|----------------------------|
|                                  | Pounds              | Pounds |                            |
| In 2,000,000 pounds surface soil | 3440                | 1540   | Neutral to slightly acid.  |
| In 2,000,000 pounds subsoil      | 2960                | 1300   | Alkaline to slightly acid. |



The surface soil of the Sharkey clay is a dark drab or grayish brown silty clay, usually mottled with brown. This usually passes at rather widely varying depths into drab, steel gray or bluish sticky clay, although rather frequently there is little change in either texture or color in the 3-foot section. Frequently there is considerable sand found in the immediate surface.

The Sharkey clay may run rather uniform in character over a wide area, while in other localities it may be badly spotted with sand blows. These sand blows are usually somewhat rounded or oval mounds 20 to 40 feet in diameter, and varying from a few inches to 2 or even 3 feet higher than the surrounding level-lying typical Sharkey clay.

The Sharkey clay is one of the most frequently occurring types in the Mississippi bottoms, where it is known as "buckshot land" because of its ability to granulate and form a desirable crum structure. Were it not for this tendency to granulate the Sharkey clay would be very difficult to handle, due to its high clay content. Fortunately the land can be plowed when quite wet and the soil instead of forming into hard clods as it dries out, breaks down into granular structure, or if clods do form they are usually slaked by the first rain.



In the section where Sharkey clay predominates and in fact throughout much of the Delta section, the background is always timber. This gives the impression that there is much uncleared land. Such may not be the case as frequently the timbered strip is only a few rods wide along some wet slough.

Under natural conditions the type was poorly drained and supported a heavy growth of hardwood, with some cypress. Large drainage projects have been carried through and a considerable portion of this land has been brought under cultivation, although there is still much to be cleared, drained, and brought under the plow.

The Sharkey clay is one of the strongest soils in the state, and is well supplied with both total nitrogen and phosphorus. Over most of the type lack of proper drainage is of far greater importance than lack of sufficient plant food.

As the type is only slightly acid to neutral in reaction, alfalfa does well on the well drained areas without the use of lime.

#### WAVERLY SILT LOAM

|                                  | Nitrogen Phosphorus |        |                                      |
|----------------------------------|---------------------|--------|--------------------------------------|
|                                  | Pounds              | Pounds | Reaction                             |
| In 2,000,000 pounds surface soil | 1540                | 540    | Strongly acid to very strongly acid. |
| In 2,000,000 pounds subsoil      | 960                 | 380    | Very strongly acid.                  |

Frequently there is little change in the character of the Waverly silt loam when examined to a depth of 36 inches, the main differences found being a decrease in the amount of organic matter present and a slight increase in the amount of clay found as depth increases. Through the entire section the soil consists usually of a gray silt loam with an occasional streak of yellow. The section as a whole is rather compact, almost impervious to water, and becomes even more resistant to the movement of water with increased depth. This very compact material may in places be found nearer to the surface than 36 inches.

The type occupies poorly drained, flat areas in the first bottom. The larger portion of the type is timbered, although there are areas in the prairie section where there is little or no timber growth. Poor drainage has held back the development of this type and before most of the type can be profitably cultivated, drainage must be provided.

Liming of this soil should follow thorough drainage as the surface soil is strongly acid and even more acidity is present in the subsoil. Two tons of ground limestone per acre would not be an excessive amount to use on this soil.

The soil is noticeably low in the total amount of phosphorus present, so that the addition of phosphorus to this soil should follow drainage and liming. In beginning the use of a phosphate the phosphate may be used at the rate of 200 pounds per acre. The amount may be increased slightly as the organic matter and nitrogen are increased.

The nitrogen content is also low when the amount present is compared with a fertile soil. A definite rotation should be adopted that will include a large use of legumes such as cowpeas to be turned under directly as a green manure, or the resulting manure turned under after being fed to animals.

The addition of organic matter in the green manure or as crop residues will have a beneficial effect on the physical char-

acter of this soil. Under present conditions the surface soil runs together and bakes badly when it dries. A good supply of organic matter in the soil will have a decided effect in correcting such a condition.

#### WAVERLY CLAY

|                                 | Nitrogen Phosphorus |        |                                      |
|---------------------------------|---------------------|--------|--------------------------------------|
|                                 | Pounds              | Pounds | Reaction                             |
| In 2,000,00 pounds surface soil | 2620                | 1120   | Strongly acid to very strongly acid. |
| In 2,000,000 pounds subsoil     | 1140                | 720    | Very strongly acid.                  |

The surface soil of the Waverly clay is a brownish gray to gray clay loam or clay, the lighter textured areas occurring near the banks of streams and the heavier phase back in the region of the more quiet overflow water. The subsoil consists of gray or drab material little different in texture from the surface. Occasionally yellow mottlings appear, this condition usually being found associated with the coarser textured materials occupying the higher ground.

The Waverly clay is found in the first bottoms, being closely related to the Waverly silt loam into which it grades. This soil is of flat topography, and this, together with its rather impervious nature, makes the type poorly drained. As with the Waverly silt loam drainage is of first importance. When reclaimed this will prove to be a stronger soil than the silt loam.

The Waverly clay is decidedly acid and the question of liming is one of the first to consider after the land has been drained. After thorough drainage it will likely prove profitable to apply as much as 2 tons of ground limestone per acre.

The Waverly clay is fairly well supplied with both nitrogen and phosphorus. The adoption of a system of rotation which will increase the organic matter content of the soil will be an advantage as the organic matter will help to put the soil in better physical condition, a thing which is very desirable. The addition of fresh organic matter will tend to produce more available nitrogen and in time it likely will prove profitable to use some material carrying phosphorus.

#### YAZOO SILT LOAM

|                                  | Nitrogen Phosphorus |        |                     |
|----------------------------------|---------------------|--------|---------------------|
|                                  | Pounds              | Pounds | Reaction            |
| In 2,000,000 pounds surface soil | 1560                | 1320   | Strongly acid.      |
| In 2,000,000 pounds subsoil      | 1460                | 1020   | Very strongly acid. |

The Yazoo silt loam is a light brown or grayish brown incoherent silt loam 6 to 8 inches in depth. Immediately below the surface is usually found a decided gray layer of slightly

heavier material, which passes quickly at from 15 to 20 inches into a mottled drab to yellow stiff, plastic clay. This dense clay may continue throughout the 3-foot section, although frequently below 30 inches the subsoil becomes more silty and less tenacious.

Although one of the higher lying types of the Mississippi River bottoms, the Yazoo silt loam is not very well drained. This is due largely to the compact clay layer in the subsoil, which interferes with the movement of water through the subsoil. This condition has also helped to bring about a strong acidity in the soil.

This soil is fairly well supplied with total phosphorus, but the nitrogen content is low. The increase of the nitrogen and organic matter content through turning under legumes is advisable. When the land is fairly well drained the use of lime in connection with the legumes should be considered.

#### YAZOO SILTY CLAY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                  |
|----------------------------------|---------------------|--------|---------------------------|
|                                  | Pounds              | Pounds |                           |
| In 2,000,000 pounds surface soil | 3020                | 1520   | Neutral to slightly acid. |
| In 2,000,000 pounds subsoil      | 1260                | 1260   | Neutral to strongly acid. |

The surface soil of the Yazoo silty clay loam consists of a brown silty clay loam to silty clay, which passes at from 8 to 12 inches into the yellowish brown, brownish yellow, or yellowish drab tough heavy clay subsoil.

The Yazoo silty clay loam is a first bottom soil found in the Mississippi lowlands. It is naturally somewhat better drained than the Sharkey clay, which occupies wide areas in the same section.

The type is fairly well supplied with both total nitrogen and phosphorus. It is neutral to slightly acid. The small amount of acidity does not appear to be injurious to alfalfa as this crop is being successfully grown on the type.

#### Terrace or Second Bottom

##### BISCOE SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                       |
|----------------------------------|---------------------|--------|--------------------------------|
|                                  | Pounds              | Pounds |                                |
| In 2,000,000 pounds surface soil | 1900                | 1020   | Neutral to very slightly acid. |
| In 2,000,000 pounds subsoil      | 1180                | 860    | Very slightly acid.            |

The surface soil of the Biscoe silt loam is a grayish brown to brown silt loam, with enough sand in its make-up to produce

a soil of good physical properties, being loose and easily cultivated. The yellow subsoil is of slightly heavier material, although even the subsoil is open enough to make rapid movement of water through the subsoil possible.

The type, which is second bottom, is found at elevations from nothing to as much as 20 feet above the adjacent first bottom lands. This higher elevation, coupled with the undulating surface and the open textured soil, make the type as a whole very well drained.

Liming this soil for general farm crops is not to be recommended at present. However, where alfalfa is to be seeded, and alfalfa should do well on this type, the application of a ton of ground limestone per acre will likely prove profitable.

The soil is only fairly well supplied with both nitrogen and phosphorus. Attention should be paid to the increase of the nitrogen content of the soil. This can easily be accomplished on this soil as most legumes do very well. The legume crops may either be pastured off or turned under as green manure.

Along with the increase of nitrogen and organic matter should go the addition of phosphorus carrying materials. The use of acid phosphate at the rate of 200 to 250 pounds per acre is suggested.

This soil is a productive one in its present state, but will respond readily to better treatment.

#### CALHOUN SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                    |
|----------------------------------|---------------------|--------|-----------------------------|
|                                  | Pounds              | Pounds |                             |
| In 2,000,000 pounds surface soil | 1750                | 600    | Acid to strongly acid.      |
| In 2,000,000 pounds subsoil      | 1520                | 640    | Acid to very strongly acid. |

The Calhoun silt loam is a light gray to almost white incoherent silt loam, which passes at from 6 to 12 inches into a compact drab or yellowish drab clay, frequently streaked with red. Frequently just above the tough clay there is a layer of almost white floury silt.

The Calhoun silt loam is a second bottom or terrace type found in the lowlands of East Arkansas. It is known as "flats", "whiteland", and "buckshot land". The last term is rather confusing, as the same term is applied to another type of soil of entirely different nature. In the case of the Calhoun silt loam the term "buckshot" arises from the large number of iron concretions, which resemble buckshot, that are found not only on the surface but through the soil. The type is flat and has poor surface drainage, and the compact clay subsoil permits only slow movement of water downward.

The Calhoun silt loam is not well supplied with either total

nitrogen or phosphorus. It is also acid to strongly acid. The removal of excess water, however, is of greatest importance and should come before the use of commercial fertilizers or lime. Where thorough drainage can not be considered, plowing the land in wide beds, i. e., 15 steps wide, and leaving the dead furrows open will be of benefit. The increase of the organic matter content is of second importance to drainage.

#### CALHOUN CLAY

|                                  | Nitrogen Phosphorus |        | Reaction            |
|----------------------------------|---------------------|--------|---------------------|
|                                  | Pounds              | Pounds |                     |
| In 2,000,000 pounds surface soil | 2980                | 1260   | Strongly acid.      |
| In 2,000,000 pounds subsoil      | 1180                | 640    | Very strongly acid. |

The surface soil of the Calhoun clay varies from a heavy silt loam to a gray clay. The subsoil is a heavy tenacious and rather impervious clay, usually of a gray or drab color.

The type is found as second bottom in the region lying west of Crowley's Ridge. This type was originally timbered and much of it is still uncultivated. Although the type is second bottom and lies considerably higher than some of the surrounding land, still it is not well drained because the surface is flat and water is inclined to remain on the surface due to the almost impervious subsoil.

Thorough drainage is the first essential in the improvement of this land, followed by liming. The type has a fair supply of total nitrogen, but the addition of organic matter, which will increase the amount of available nitrogen and also help to improve the physical condition of the soil, will be highly beneficial.

After drainage, liming, and the addition of organic matter have been taken care of, acid phosphate may be used with profit. As the Calhoun clay contains a fair supply of total phosphorus when compared to its nitrogen content, acid phosphate should not be used until more organic matter is turned into the soil unless growth of crops indicates an excess of available nitrogen, i. e., large growth of stalk with poor fruiting.

#### CROWLEY SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                             |
|----------------------------------|---------------------|--------|--------------------------------------|
|                                  | Pounds              | Pounds |                                      |
| In 2,000,000 pounds surface soil | 2540                | 420    | Strongly acid to very strongly acid. |
| In 2,000,000 pounds subsoil      | 1300                | 240    | Very strongly acid.                  |

The surface soil of the Crowley silt loam is a gray to brown gray silt loam. In its virgin state, or where it has not been heavily cropped, it is fairly well supplied with organic matter,

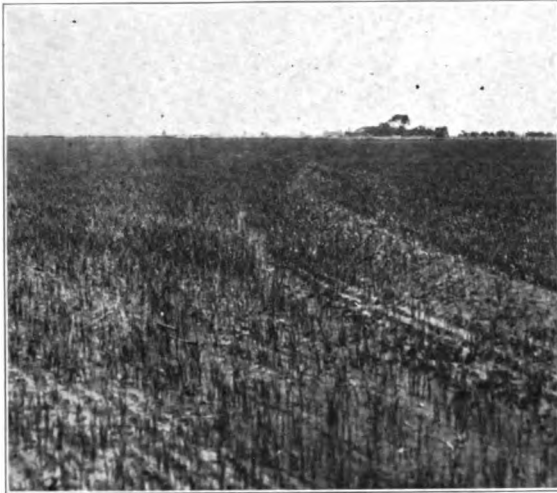
and with its loose, open structure has excellent working qualities.



Pumping water for rice irrigation on the Crowley silt loam.

The subsoil is also a silt loam of gray or yellowish gray color, changing with depth into a gray silty clay and finally into a heavy clay usually mottled with yellow and red. This lower subsoil is very compact and almost impervious to water. This tight clay or so-called "hardpan" is a very important factor in the production of general farm crops, as it interferes with both the downward movement of water when the land is wet and with the upward movement when a drought sets in, making this soil very much affected by moisture conditions. In the production of rice, however, to which a large portion of this type is devoted, the tight subsoil is an advantage as little water is lost by percolation through the soil.

This soil is the typical prairie soil of East Arkansas and occurs in largest continuous bodies in Lonoke, Prairie, and Arkansas Counties, although smaller areas of similar nature are found extending southward through Lincoln, Drew, and Ashley Counties. The most of the type has a rather level to gently undulating topography, and this topography together with the rather impervious subsoil makes much of the type somewhat poorly drained, in spite of the fact that as a general rule this soil occupies the higher elevations in the region where found. This



Crowley silt loam, levee used in irrigation in foreground.

relatively high elevation makes possible a good fall where drainage work is carried on.

The Crowley silt loam is strongly acid and the use of ground limestone at the rate of  $1\frac{1}{2}$  to 2 tons is recommended, where crops easily affected by soil acidity are grown.

The phosphorus content is decidedly low and the use of fertilizers carrying large amounts of phosphorus should be adopted, as the Crowley silt loam contains a relatively large amount of nitrogen as compared with the phosphorus content.

The use of limestone and acid phosphate, the growing of legumes in the rotation, with careful handling of crop residues and manure produced, together with good methods of cultivation, will increase the productiveness of this soil. A large acreage of hay and pasture crops may be utilized on much of this type as dairying has come to be of considerable importance in parts of this section.

The level topography, the impervious subsoil and the large supply of water available in the beds of sand and gravel below this prairie section, make the Crowley silt loam unusually well adapted to the production of rice. After levees are constructed and the pumping plant equipped, rice farmers can not be blamed for running the land in rice for several years. However, much more can be done in the way of adopting rotation than is done at present, for grasses, peas, and winter oats should do well.





• Drainage ditch in rice field on the flat-lying Crowley silt loam.

#### LINTONIA FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction               |
|----------------------------------|---------------------|--------|------------------------|
|                                  | Pounds              | Pounds |                        |
| In 2,000,000 pounds surface soil | 1220                | 680    | Neutral to acid.       |
| In 2,000,000 pounds subsoil      | 840                 | 540    | Slightly acid to acid. |

The soil of the Lintonia fine sandy loam is a brown fine sandy loam, varying from 8 to 15 inches in depth. This is underlain by a yellowish brown fine sandy loam, which grades with depth into a yellowish brown sandy clay. Occasionally the subsoil is rather stiff, but usually it has a good physical condition. Sandblows are rather common, especially on the type east of Crowley's Ridge. These spots consist of a brownish sand underlain by grayish or yellowish sand.

The Lintonia fine sandy loam is a terrace or second bottom type, occurring on low-lying ridges usually extending in a general north and south direction. The Lintonia silt loam, a soil somewhat better supplied with plant food, usually occupies the flatter portions of these ridges, while the fine sandy loam is found on the more undulating portions of the ridges. The soil as a whole is well drained, and likely it is due to this fact that so many small areas of the type have been selected as sites upon which to locate houses.

The Lintonia fine sandy loam is not well supplied with either nitrogen or phosphorus, although the yields obtained on the type are good. The soil has a very desirable physical condition



The Lintonia fine sandy loam usually occurs on rather well drained low ridges running through the Delta section. A considerable acreage of this type is given over to the production of oats.

so that a relatively large proportion of the total plant food present is made available during a season. This type was one of the first soils cleared in this portion of the state, so that most of it has been cropped for years. This continued cropping has resulted in a lowering of the plant food content, so that a comparison of the nitrogen and phosphorus in this soil with that found in other types of the same section is rather unfavorable. This soil as a whole is one of the best types of the terrace section and is highly prized.

For permanent improvement of this type it will be necessary to use phosphorus carrying fertilizers and grow legumes, turning a good portion into the soil to build up the organic matter and nitrogen content. Cowpeas make a vigorous growth on this soil. For the present, in fertilizing cotton it will usually pay best to use a complete fertilizer. One analyzing approximately 10-4-2 is suggested.

The soil varies from neutral to acid in reaction. Where the soil is known to be acid the use of 1 to 1½ tons of ground limestone to the acre will prove profitable where legumes sensitive to soil acidity are grown.

#### MORSE CLAY

|                                  | Nitrogen Phosphorus |        | Reaction            |
|----------------------------------|---------------------|--------|---------------------|
|                                  | Pounds              | Pounds |                     |
| In 2,000,000 pounds surface soil | 1480                | 580    | Acid.               |
| In 2,000,000 pounds subsoil      | 640                 | 400    | Very strongly acid. |

The surface soil of the Morse clay is a gray to yellow gray

clay loam or clay. The yellower color usually is found along with the heavier surface. This condition is ordinarily found on the steeper slopes where a large portion and sometimes practically all of the original surface has been removed by erosion.

The subsoil is a heavy clay varying from yellow to red color. Where this subsoil has been exposed or comes near the surface due to the removal of the surface soil, a very undesirable condition results.

The type is found in connection with the Crowley and Calhoun silt loams, being formed in a large measure by the removal of the surface soils of these two types leaving the underlying materials to form a soil.

While as far as plant food is concerned most of the Morse clay is as well supplied as many of the soils of this section, still its physical condition and topography make it less productive and therefore less desirable. Some areas of the Morse clay are so intractable that they are allowed to lie out. Cowpeas usually will make a very good growth.

Improvement of this type should include first of all the checking of erosion and the addition of fresh organic matter, to be followed by liming and later by judicious use of commercial fertilizers, relying mainly on acid phosphate.

#### OLIVIER SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                             |
|----------------------------------|---------------------|--------|--------------------------------------|
|                                  | Pounds              | Pounds |                                      |
| In 2,000,000 pounds surface soil | 2200                | 840    | Slightly acid to strongly acid.      |
| In 2,000,000 pounds subsoil      | 1170                | 860    | Strongly acid to very strongly acid. |

The Olivier silt loam is a light brown to brown silt loam 6 to 10 inches in depth, which passes into a light brownish gray or yellowish gray mottled with reddish brown silty clay loam. This passes with depth into a drab or gray compact silty clay or clay, mottled with reddish brown.

The Olivier silt loam is a terrace type found in the lowlands of East Arkansas, where it is found associated with the Calhoun silt loam. It occupies generally level country, but as it usually lies higher than the Calhoun silt loam it has better surface drainage. The subsoil of the Olivier silt loam is very similar to that of the Calhoun silt loam, being almost impervious to water, this causing poor under-drainage.

The soil is not well stocked with either total nitrogen or phosphorus, and after drainage has been established both of these elements should be supplied. The soil is slightly acid to strongly acid. Where the land is drained the use of lime will prove profitable.

**Arkansas and Red River Bottoms****First Bottom****MILLER CLAY**

|                                  | Nitrogen Phosphorus |        |                                 |
|----------------------------------|---------------------|--------|---------------------------------|
|                                  | Pounds              | Pounds | Reaction                        |
| In 2,000,000 pounds surface soil | 2810                | 1560   | Neutral to very slightly acid.  |
| In 2,000,000 pounds subsoil      | 1760                | 1140   | Alkaline to very slightly acid. |

The Miller clay is a chocolate red to dark chocolate red clay, which frequently continues with little change through 36 inches in depth, although more commonly below 10 to 16 inches brighter red colored clay is found.

The Miller clay occurs in the Arkansas and Red River bottoms, frequently found in connection with the Portland clay. It usually lies several feet lower than the surrounding soils, and for this reason is naturally poorly drained.

This type is fairly well supplied with total nitrogen and well supplied with phosphorus. As with the Portland clay, drainage is the important factor, rather than increasing the plant food supply.

The Miller clay is usually well supplied with lime; in fact the subsoil is highly calcareous. The high lime content favors good granulation so that the soil breaks down readily into small granules, which condition gives rise to the term "buckshot land". This high lime content also favors the growth of alfalfa, the acreage of which should be increased as drainage is established.

**PORTLAND VERY FINE SANDY LOAM**

|                                  | Nitrogen Phosphorus |        |                   |
|----------------------------------|---------------------|--------|-------------------|
|                                  | Pounds              | Pounds | Reaction          |
| In 2,000,000 pounds surface soil | 2380                | 1220   | Neutral to acid . |
| In 2,000,000 pounds subsoil      | 1360                | 1040   | Slightly acid.    |

The Portland very fine sandy loam is a light brown to chocolate brown very fine sandy loam, which passes at from 6 to 10 inches into lighter colored or pinkish material of about the same texture. This material passes with depth into a light reddish brown to chocolate red silty clay loam or silty clay.

The type is usually found occupying the higher elevations in the bottoms of the Arkansas and Red Rivers, and is flat to very gently undulating. The type as a whole, even under natural conditions, is fairly well drained.

The Portland very fine sandy loam is a productive soil and one of the most important types in the Arkansas River bottoms.

Being naturally well drained and easily worked it was one of the first soils brought under cultivation, practically all of the type having been farmed for years.



A scene on the Portland very fine sandy loam, one of the best soils of the Arkansas River bottom.

The type is only fairly well supplied with nitrogen and phosphorus. On the more worn portions the nitrogen content will be found to be considerably lower than this average figure. The fine physical condition of this soil makes possible remarkably good yields considering the amount of plant food found in the soil. Few soils can be found anywhere that are more easily handled than the Portland very fine sandy loam.

The organic matter and nitrogen content should be increased by growing and turning under legumes. The use of both nitrogen and phosphorus in a commercial fertilizer on cotton will pay on the more worn portions of the type.

The soil is only slightly acid to acid in reaction. Where alfalfa is to be seeded the use of from 1 to 2 tons of ground limestone per acre is advisable.

#### PORTLAND CLAY

|                                  | Nitrogen Phosphorus |        | Reaction                  |
|----------------------------------|---------------------|--------|---------------------------|
|                                  | Pounds              | Pounds |                           |
| In 2,000,000 pounds surface soil | 3740                | 1520   | Neutral to slightly acid. |
| In 2,000,000 pounds subsoil      | 2400                | 1240   | Neutral to acid.          |

The Portland clay, one of the "buckshot lands" of the Ar-

kansas River bottoms, is a chocolate brown to yellowish brown silty clay or clay, which is frequently mottled with drab and gray, especially in the more poorly drained areas. This brownish clay passes with depth into a chocolate red or peculiar pinkish sticky clay.

The Portland clay occupies wide areas in the Arkansas and Red River bottoms, and in the bottoms of the Mississippi River south of its junction with the Arkansas. As a general rule it is low and flat, so that under natural conditions water remains on the surface for long periods over a large portion of the type. This soil also frequently occurs as a narrow strip along sloughs that meander through the higher lying Portland very fine sandy loam. Here standing water may be found throughout the year, a condition which encourages a growth of cypress.

The Portland clay is well supplied with both total nitrogen and phosphorus; in fact it is one of the strongest soils in the state. In spite of this fact a large portion of the type is still timbered. The poor natural drainage and the difficulties of working a heavy soil are in large measure responsible for the undeveloped condition of the type. With the highly desirable Portland very fine sandy loam lying near by it is not surprising that the heavier, lower-lying type should have to await development.

Thorough drainage is of first importance on this type. Development along this line has already been begun, and when completed and the land cleared a fine body of land will be opened up for cultivation.

The soil is neutral to slightly acid. Alfalfa should prove to be a profitable crop on well drained areas.

#### YAHOLA VERY FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction |
|----------------------------------|---------------------|--------|----------|
|                                  | Pounds              | Pounds |          |
| In 2,000,000 pounds surface soil | 1500                | 740    | Neutral. |
| In 2,000,000 pounds subsoil      | 840                 | 640    | Neutral. |

The Yahola very fine sandy loam consists of a light chocolate brown to reddish brown very fine sandy loam, which passes at from 10 to 20 inches into a light chocolate-red or salmon-pink colored very fine sandy loam to a very fine sand. In the deeper subsoil lighter colored material of still coarser texture is found, the lower subsoil being frequently made up of fine or very fine sand.

The type occupies rather long, narrow areas roughly paralleling the stream usually not far distant from the stream banks. The type occupies some of the higher elevations in the bottom lands and on the whole is well drained.

This type is not well supplied with total nitrogen and phos-

phorus, but gives surprisingly good yields of corn or cotton when the total amount of these plant foods in this soil is considered. The soil is of splendid physical makeup, and this helps to offset the small amounts of these elements present. The type responds readily to good management, which on this type should include the use of acid phosphate and the turning under of green manures, preferably legumes.

The type is generally neutral in reaction, so that lime is not recommended for general use on this type. Alfalfa will do well on most of the type without the use of lime. On some of the lower-lying, flat areas, the use of lime on alfalfa will prove profitable.

#### YAHOLA SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction |
|----------------------------------|---------------------|--------|----------|
|                                  | Pounds              | Pounds |          |
| In 2,000,000 pounds surface soil | 2200                | 880    | Neutral. |
| In 2,000,000 pounds subsoil      | 1340                | 720    | Neutral. |

The Yahola silt loam is a rather friable chocolate brown soil passing rather quickly into a compact silt loam of slightly lighter color, this material being underlain by a very fine sandy loam to a very fine sand of still lighter color.

Although this soil is inclined to run together and bake more after a rain than the very fine sandy loam, still this is a rather easy soil to handle. This type is usually found in the lower, flatter lands close to the Yahola very sandy loam.

The silt loam contains more total phosphorus and total nitrogen than the very fine sandy loam, and yet the silt loam does not contain as much total plant food as a good soil should. Legumes should be given a large place in the rotations adopted on this land, and in connection with the turning under of legumes, acid phosphate at the rate of 250 pounds per acre can be profitably used.

As this soil is neutral in reaction, the general use of lime is not to be recommended.

#### Terrace or Second Bottom

##### BASTROP CLAY

|                                  | Nitrogen Phosphorus |        | Reaction             |
|----------------------------------|---------------------|--------|----------------------|
|                                  | Pounds              | Pounds |                      |
| In 2,000,000 pounds surface soil | 2840                | 1520   | Neutral to alkaline. |
| In 2,000,000 pounds subsoil      | 1840                | 920    | Alkaline to neutral. |

The Bastrop clay is a dark reddish brown to dark chocolate brown silty clay or clay, which is underlain by a chocolate red to chocolate brown clay, which becomes more compact with depth.

The Bastrop clay is a terrace type, and as a general rule is fairly well drained. The type is rather unimportant as far as total area is concerned, yet because of its fertility it is important in the locality where it is found.

The Bastrop clay is a heavy soil and becomes very sticky when wet. Being well supplied with lime and also with a fair amount of organic matter present, the surface soil crumbles fairly well when it dries out provided the land is not worked when too wet. If the organic matter content of this soil is maintained or increased this soil should continue to remain in fairly good tilth for a clay soil.

Bastrop clay is fairly well supplied with both nitrogen and phosphorus, being as well stocked with these materials as any soils in the area in which this type is found.

If organic matter is turned into this soil so that we have considerable active or rapidly decomposing organic matter present the producing powers of this soil should be maintained. Being fairly well supplied with total phosphorus the use of acid phosphate on this type is not to be recommended till the farmer has tried out its use on a small scale and found that profitable returns are obtained.

As this soil is neutral the application of limestone is not recommended, at least at present.

#### BREWER VERY FINE SANDY LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                  |
|----------------------------------|---------------------|--------|---------------------------|
|                                  | Pounds              | Pounds |                           |
| In 2,000,000 pounds surface soil | 1960                | 820    | Neutral.                  |
| In 2,000,000 pounds subsoil      | 960                 | 700    | Neutral to slightly acid. |

The Brewer very fine sandy loam is a brown or dark brown very fine sandy loam, which passes with depth into a lighter colored material of only slightly heavier texture. Frequently throughout the 3-foot section the material is a very fine sandy loam, although the subsoil usually consists of a light brown silty loam. Occasionally layers of clay of a few inches thickness are found in the subsoil.

The type occupies some of the higher portions of the second bottoms or terraces and is well drained.

The Brewer very fine sandy loam is not very well supplied with either nitrogen or phosphorus when compared with some of the associated bottom land types. However, its splendid physical makeup, which makes the soil easily handled, makes it one of the most desirable soils of the areas in which it is found.

An increase of the organic matter and nitrogen content through the growing of legumes, and the use of acid phosphate is recommended. Legumes, even alfalfa, will do well on this soil



with proper treatment, as the soil is naturally well drained and is generally not acid.

#### BREWER SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                       |
|----------------------------------|---------------------|--------|--------------------------------|
|                                  | Pounds              | Pounds |                                |
| In 2,000,000 pounds surface soil | 2120                | 760    | Neutral to very strongly acid. |
| In 2,000,000 pounds subsoil      | 1720                | 620    | Very slightly acid to acid.    |

The Brewer silt loam consists of a dark brown to black silt loam, which passes at 12 to 18 inches into a dark brown clay loam or dark drab clay. Where the type has best drainage light brown or reddish brown colors are common in the subsoil.

The Brewer silt loam is found on the terraces at a slightly lower elevation than the Brewer very fine sandy loam. On the whole the type is fairly well drained and practically all of the type is under cultivation.

The Brewer silt loam is not as rich in nitrogen and phosphorus as might be expected from the good yields of crops obtained, as the type contains little more total nitrogen than the Brewer very fine sandy loam. An increase of the nitrogen content through the turning under of legume crops and residues and the use of phosphatic fertilizers is advised.

Very likely but little benefit will be derived from the use of ground limestone on most of the type, except when used on crops, such as alfalfa, which are very sensitive to acid conditions.

#### BREWER CLAY

|                                  | Nitrogen Phosphorus |        | Reaction                  |
|----------------------------------|---------------------|--------|---------------------------|
|                                  | Pounds              | Pounds |                           |
| In 2,000,000 pounds surface soil | 2680                | 1100   | Neutral to slightly acid. |
| In 2,000,000 pounds subsoil      | 1580                | 620    | Neutral to slightly acid. |

The Brewer clay is a dark brown to black silty clay loam to clay, which passes with depth into a dark drab or bluish black, plastic, sticky clay.

The Brewer clay is a terrace type occupying as a general rule still lower elevations than the Brewer silt loam. The clay frequently occurs in small depressed areas throughout the large areas of the silt loam.

Because of its high content of clay this soil becomes very sticky when wet, and if worked when too wet becomes very cloddy. As the soil dries out large cracks are developed which tend to break many roots of growing crops. Where this soil is properly handled cotton appears to stand dry weather very well.

The Brewer clay is one of the strongest soils in the regions where the type occurs, being fairly well supplied with both nitrogen and phosphorus.

Probably the chief need of this soil is better drainage. The narrow range of moisture content when the soil can be worked without danger of injury to the soil makes the preparation of a good seed bed almost impossible on much of the type during the majority of spring seasons. With better drainage more opportunity for working the land will be afforded.

Only small returns can be expected from the use of lime on this type; in fact alfalfa does well on some of this soil where the drainage problem has been solved.

#### MUSKOGEE VERY FINE SANDY LOAM

|                                  | Nitrogen<br>Pounds | Phosphorus<br>Pounds | Reaction                             |
|----------------------------------|--------------------|----------------------|--------------------------------------|
| In 2,000,000 pounds surface soil | 1100               | 440                  | Very slightly acid to slightly acid. |
| In 2,000,000 pounds subsoil      | 680                | 400                  | Slightly acid.                       |

The Muskogee very fine sandy loam is a yellowish gray fine sandy loam, underlaid by fine sandy clay subsoil of a gray and red or gray and yellow color. On poorly drained areas the gray and yellow predominates. The substratum is usually a chocolate red clay.

This type is found as a terrace or second bottom soil. It is rather unimportant, both from a standpoint of extent of area and agricultural value.

The phosphorus content of the Muskogee very fine sandy loam is noticeably low. In increasing the productivity of this soil the use of highly phosphatic fertilizers should be adopted. The soil is also low in organic matter and nitrogen content. The growing and turning under of legume crops will not only increase the organic matter and nitrogen content of the soil, but will also help to hold moisture during the growing season, and this will result in making this soil more resistant to drought.

The Muskogee very fine sandy loam is only slightly to very slightly acid. For the time being at least, money spent for fertilizers such as acid phosphate, will very likely give one larger returns than money put into ground limestone.

#### MUSKOGEE SILT LOAM

|                                  | Nitrogen<br>Pounds | Phosphorus<br>Pounds | Reaction                    |
|----------------------------------|--------------------|----------------------|-----------------------------|
| In 2,000,000 pounds surface soil | 1360               | 740                  | Slightly acid to acid.      |
| In 2,000,000 pounds subsoil      | 800                | 600                  | Acid to very strongly acid. |

The surface soil of the Muskogee silt loam is a yellowish

gray, or pale yellow silt loam, which usually quickly passes into a silty clay loam mottled with yellow and gray. The subsoil is usually a yellowish red or reddish yellow clay with some gray mottlings.

Muskogee silt loam is a terrace type, being found as second bottom land along the Arkansas River. It lies in flatter, lower areas than the Muskogee very fine sandy loam, and is, therefore, more poorly drained.

The Muskogee silt loam is slightly better supplied with total nitrogen and much better supplied with total phosphorus than the Muskogee very fine sandy loam. An increase in the nitrogen supply in this soil is imperative before the more profitable crops can be produced. The nitrogen supply should be increased by growing legumes and turning them into the soil. Where the land is completely drained very likely light applications of acid phosphate will result in profitable returns, and as the nitrogen and organic matter content of the soil is increased the applications of acid phosphate may be increased. For the present where cotton is grown it will be well to use a fertilizer analyzing approximately 9-3-0, at the rate of 400 pounds per acre.

Before considerable areas of this soil can be made to produce best results it will be necessary to install artificial drainage. Some of the higher and more undulating portions of the type are fairly well drained under natural conditions. A large portion of the type is inclined to be flat and wet.

On the better drained areas of this type the use of ground limestone at the rate of one ton per acre is recommended.

#### REINACH SILT LOAM

|                                  | Nitrogen Phosphorus |        | Reaction                       |
|----------------------------------|---------------------|--------|--------------------------------|
|                                  | Pounds              | Pounds |                                |
| In 2,000,000 pounds surface soil | 2900                | 750    | Neutral.                       |
| In 2,000,000 pounds subsoil      | 1780                | 520    | Neutral to very slightly acid. |

The Reinach silt loam is a chocolate brown to dark brown silt loam, which passes at from 8 to 10 inches into a lighter colored, more compact material of the same texture. The lower subsoil usually changes into a lighter colored, coarser textured material varying from a very fine sandy loam to a very fine sand. The subsoil has a grayish cast, yet even here the chocolate red color found in the surface soil can be detected.

The Reinach silt loam occurs on the terraces along the Arkansas River. It is somewhat similar to the Yahola silt loam both as to texture and structure; that is, the surface soil lies

on a lighter textured or sandier subsoil. The Reinach silt loam, however, is above overflow.

The Reinach silt loam is one of the most fertile soils of the region in which the soil is found. It is fairly well supplied with total nitrogen, although it is rather low in total phosphorus. The nitrogen and organic matter content of the soil should be maintained through the growing and turning under of legume crops and by the use of winter cover crops, such as rye. Acid phosphate can very profitably be used, especially in connection with alfalfa, which should do well on this soil.

As the Reinach silt loam is neutral very likely the application of ground limestone will not be profitable, unless it be on alfalfa, which is very susceptible to soil acidity.







4.  
**UNIVERSITY OF ARKANSAS**

**COLLEGE OF AGRICULTURE**

**Department of Home Economics**

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**TABLE SERVICE AND ETIQUETTE  
FOR THE HOME**

By

**CARRIE H. PLUNKETT**

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**BULLETIN NO. 188**

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**FAYETTEVILLE, ARKANSAS**

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The Bulletins of this Station are sent free to all residents of the State who request them.



## FOREWORD

It has been said that much of the comfort, cheerfulness, and refinement of a family depends on attractive table service. This being true, the woman who presides over a household cannot afford to treat the subject with indifference. Much of the printed literature on table service deals largely with formal and semi-formal types, the carrying out of which requires one or more servants. Since the majority of families now a-days have no servants, it seems only fitting that more information on informal or family-type service should be made available. The realization of such a need prompted the writing of this bulletin which deals with table etiquette, family-type table service, and service for special occasions. Since good authorities differ on details and every resourceful housewife exhibits her own individuality, fundamental principles, rather than infallible rules, have been given.

## TABLE ETIQUETTE

The behavior of an individual at the dining table, possibly more than at any other place, betrays his social training and natural refinement. Customs in table etiquette change from year to year, and also differ slightly in different localities. For this reason no set of approved rules can always be followed. There is never a time, however, when tact and consideration for others cannot be practiced. These after all form the basis of all good manners.

**Guests to Meals.**—Only guests who are thought to be congenial should be invited to the same meal. An invitation to a meal requires an immediate answer, accepting or declining. The failure to keep an engagement is an unpardonable offense.

The hostess states the hour of the meal when she extends the invitation and should so arrange her work as to be able to greet her guests, upon their arrival, without a look of fatigue or anxiety. The last kitchen preparations should not take more than ten minutes of her time. Guests are expected to arrive five or ten minutes before the appointed hour in order that they may greet the hostess, host, and one another. A guest who is delayed by circumstances beyond his control should take his place at the table quietly, with a brief apology to the hostess. The hostess need not wait longer than fifteen minutes on a late guest. A late guest is greeted by the host only, since the hostess cannot leave her duties at the table.

A guest should tarry after a meal for at least twenty or thirty minutes. On departing, he should take leave of the host and hostess, expressing an appreciation of their hospitality. A call upon the hostess should be made within two weeks after an invitation. In case one is leaving town, a note of thanks may take the place of the call.

**To the Dining Room.**—The hostess, a son, or a daughter, announces the meal. The host leads the way to the dining room with the lady-guest-of-honor, while the hostess, with the gentleman-guest-of-honor enters last.

If the hostess is to wait on the table, she sits nearest the kitchen; otherwise, she faces the kitchen. The host sits opposite the hostess. The lady-guest-of-honor sits at the right of the host, while the gentleman-guest-of-honor sits at the right of the hostess. Other guests or members of the family are seated as the hostess desires, with men and women alternating. Each person should stand back of his chair until the hostess gives the signal to be seated. Men seat the women at the table, before taking their places. One should be seated from the left and rise from the left of the chair.

**Beginning the Meal.**—The hostess is the first to take up her napkin. She keeps the conversation going; otherwise, all eyes will turn toward the host who is serving the food. When all at the table have been served, it is the hostess who first begins eating, or gives some signal for others to begin. When one's preference for food is consulted, one should express a choice at once, since to do so will aid the person who is serving.

**The Napkin.**—The napkin should be spread half unfolded on the knees. It is never permissible for an adult to use it as a bib. At the close of a single meal, in the home of a friend, the napkin is loosely folded, while it is still below the surface of the table, and placed beside the plate. A guest for more than one meal follows the example of the hostess.

**The Knife and Fork.**—In using the knife and fork together, one should hold them firmly, at an angle of forty-five degrees, in the easiest position for cutting. In this position, the tines of the fork are turned down, the point of the index finger is resting on the body of the fork, and the handle is held firmly in the palm of the hand with the other fingers and thumb. The knife is held in the same position except that the handle is placed a little farther back in the palm of the hand.

The knife is used to cut any food not soft enough to be easily broken with the fork, and to spread butter when a butter spreader is not provided. Few, if any, authorities say in writing that head lettuce may be cut with a knife; however, people with refined manners do use knives when it cannot be gracefully managed with a fork.

After having been used with the knife, the fork is transferred to the right hand, and used with tines up to carry food to the mouth. It is the correct piece of silver to use for salads, pastries, watermelons, brick ice creams, and water ices, provided they are hard frozen and served with the main part of the meal.

When not in use, the knife and fork are placed across the plate with the cutting edge of the knife to the center. They take this position when the plate is passed for a second helping of food and when the meal has been finished. The knife and fork should not be used as instruments of gesticulation, neither should they be used to mark the table cloth while one waits for food.

When using the knife to cut meat from a bone, one should cut only one bite at a time and leave any that cannot be secured with ease. When food has been started to the mouth, it should be eaten at once, rather than held suspended in the air while one converses at length with a neighbor.

**The Spoon.**—With a beverage, the spoon is used to stir and to taste. It should never be left standing in a cup or glass, since

this position is often responsible for accidents. Any liquid food correctly eaten with a spoon, is dipped toward the side of the dish farthest away from the person eating, and sipped from the side of the spoon. Creamed vegetables, if served in side dishes, soft water ices, soft custards, some fruits, desserts served with cream, and muskmelons, are eaten with a spoon. The spoon is also used to carry plum, grape, cherry, and other seeds from the mouth to the plate.

**The Fingers.**—All breads should be taken from the bread plate with the fingers. Cake, confections, wafers, hard cheese, celery, radishes, pickles, olives, and nuts should be taken with the fingers from the dishes in which they are served, when serving silver is not provided. Any of these foods should be conveyed to the mouth with the fingers.

**The Bread and Butter Plate.**—The bread and butter plate is used for butter and any bread that may be served. Jelly or jam is placed on this plate at breakfast; at dinner or at luncheon, when it is to be eaten with the main part of the meal, it is placed on the dinner or the luncheon plate.

**The Finger Bowl.**—If finger bowls are used, one bowl should be provided for each person. The tips of the fingers, one hand at a time, should be dipped into the water, and then dried with the napkin.

**General Deportment.**—An erect posture should be maintained at the dining table. It is never permissible for a person to slide down in his chair, rest his arms on the table, or crowd his neighbor.

Loud talking, a monopoly of the conversation, or heated argument at the table are indications of very bad manners.

When a guest is so unfortunate as to have an accident, he expresses regret to the hostess, who accepts his apology and promptly turns the conversation to another subject.

It is wise to eat slowly and quietly, refraining from talking while food is in the mouth.

If it is necessary to ask for something during the meal, one may speak quietly to the hostess or to the person who is waiting on the table.

It is permissible to take the last helping of any dish which may be offered one, since to refrain would look as if the supply were doubtful.

At an informal dinner, it is proper to accept a second portion of food when it is offered, provided the hostess has been served the second time. In offering a second portion, one should say "May I serve you?", "Let me give you", or "Will you have some?", rather than "May I serve you again?", or "Will you have some more?"

Since the hostess must be the last one to finish a course, it requires great skill on her part to make her food last as long as that of the thoughtless person who has spent his time talking and comes out five or ten minutes behind the others.

In passing any dish or glass at the table, care should be taken to keep the fingers on the outside. In passing a dish with a handle, the handle should be turned toward the one receiving the dish.

Refuse, such as bones, seeds, and potato shells, should be left on the plate. Salt is placed on the plate—never on the table cloth—when individual salts are not used.

If a guest does not care for a course, he should receive it anyway. More attention on his part to the conversation will make unnoticed the fact that he is not eating the food.

To tip the soup plate for the last spoonful of soup, to use bread to obtain the last drop of sauce, or to scrape the plate with a knife or fork, is likely to give the impression that one is not satisfied with the portion of food served.

It is bad form to leave the table before one has ceased chewing or before all others have finished eating. If, however, one is obliged to leave the table during the meal, one should ask permission of the hostess and go quietly.

On leaving the table, one should not push back the plate. All dishes of the last course should be left exactly as used.

A guest should not watch the manners of others, lest in so doing he neglect his own. The manners of elderly people should not be criticized, since customs change even in one generation.

The host and hostess should never allow guests to note family perplexities, neither should they drill their children on behavior after guests have arrived. Guests bringing children might well observe the same rule.

The hostess should never mention the cost of food or give an impression of hard work in its preparation. She should visit with her guests after a meal, allowing the dishes to remain unwashed for a while.

### **Personal Habits Disagreeable to Other People.**

Noisy eating or drinking.

Obtrusive use of the handkerchief.

Talking or laughing with food in the mouth.

Searching the mouth for food with the tongue.

Conveying seeds, bones, or disagreeable food directly from the mouth to the plate.

Putting fingers in the mouth.

The use of tooth picks at the table or in the presence of another.

Coughing or sneezing without turning the head.

**Blowing on food to cool it.**

**A failure to close the mouth while chewing food.**

**The Family Alone.**—The meal hour should be one of pleasure and good cheer, rather than a time to settle disputes, punish the children, or review the unpleasant happenings of the past.

Books, newspapers, and magazines are out of place at the family dining table.

The proper place to train children in table manners and in table conversation, is at the table when they are at home alone with their parents. They should be taught that the table articles are not playthings, and that the dining room is not a playground. Older children should be taught to wait on the table.

Kimonos, boudoir caps, and cook aprons should never appear at the dining table, neither should soiled shirt sleeves, collarless shirts, and dressing gowns. Personal tidiness is nowhere at a greater premium.

To criticize the food served at home is as ungracious as to criticize the food served at the home of a friend.

All members of the family should respond promptly to the announcement of a meal. The habit of coming to the table one at a time, not only tires out the person preparing the food, but is conducive to careless table manners. If one is to feel at ease in company, one must constantly practice good manners at home.

### TABLE SERVICE

**The Dining Room.**—The dining room should be a bright cheerful room so simply equipped as to make cleaning a minor process. It should contain a table suitable in size for the family, chairs, a serving table or a tea wagon, and a buffet or a sideboard.

A large rug, with nap that will not sweep out as lint, is desirable for the floor, since it will prevent unnecessary noise with the chairs.

The walls should be finished in a light, pleasing color suited to the location of the room. Only artistic pictures, if any, should be hung on the walls, and interest will be added if they are changed occasionally. Plate rails containing odd shaped dishes representing the collections of several generations, are out of date and out of place, since they serve no useful purpose. No curious collections, not wanted in other rooms, should be kept in the dining room.

The buffet is used to store linen and silver. The top, which is covered with a linen scarf, may have a bowl of flowers, or candle sticks placed upon it for decorative purposes, but it should not be used for dishes containing food. The serving table or the tea wagon, covered with a linen scarf, is used for the water

pitcher, extra silver, and dishes, and as an aid in serving and removing food and dishes.

Chairs are placed at the dining table so that the seats are even with the edge of the table. This allows enough room for one to be seated without moving the chair.

White linen for the dining table, is better than colored linen or linen embroidered in colors. Pattern cloth to fit a table of a certain size, is more expensive than cloth that can be bought by the yard. A cloth two yards long, covers a fifty-four inch round table with serving room for four people, while two and one-half yards in length are required for six people, and three and one-half yards for eight. Breakfast napkins range in size from twelve to fifteen inches square, luncheon from fifteen to twenty-two inches, and dinner size from twenty-two to twenty-seven inches square.

It is best to buy all china and glassware from open stock, in order that broken pieces may be replaced. Plated silver is much less expensive than sterling, and a good quality will last for a generation or longer.

For breakfast, supper, or luncheon, a small cloth or doilies may be used on the dining table. For dinner, a carefully laundered table-cloth, which falls ten to twelve inches below the edge of the table, should be used over a pad of canton flannel, felt, or asbestos.

A bouquet of flowers, or a growing plant, low enough for one to see over it, is a desirable decoration for the dining table. It is always possible to secure one or the other of these, if the hostess gives the matter a little time and thought.

**Setting the Table.**—With the doily service, doilies are used on the top of a polished table, one under each dish. A center-piece is used in the center of the table under the flowers, and a carving cloth under the main dish of food in front of the host. For all hot dishes, a doily should be used over the mat.

A small luncheon or breakfast cloth is placed directly on the table. A table-cloth is placed over a silence cloth or pad, with the center fold exactly in the center of the table and opposite edges of the cloth at equal distances from the floor. A doily in harmony with the shape of the table is placed in the center for the flower bowl, and a carving cloth is placed in front of the host for the main dish.

A "cover" consists of the plate, glasses, silver, and napkin to be used by one individual. An individual cover requires from twenty-four to thirty inches in width, and fifteen inches in depth, and should be placed exactly opposite the cover on the opposite side of the table.

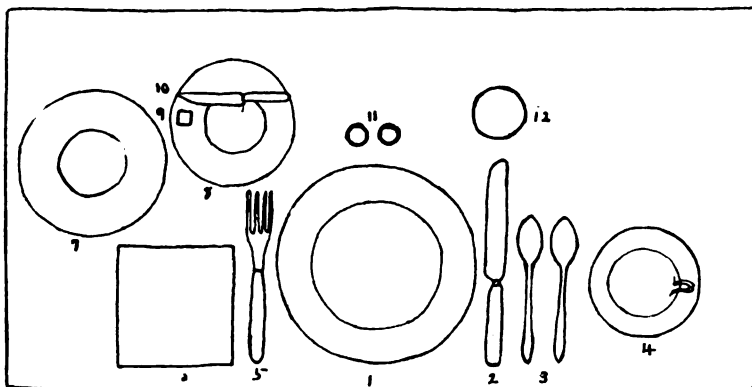
All silver, linen, and dishes in a cover are placed one inch from the edge of the table. The cover is usually marked by the

dinner knife and fork, the knife being placed on the right, sharp edge in, and the fork on the left, tines up, with room enough between them for any plate that may be used. When no knife is used, the fork is placed on the right. Spoons are placed to the right of the knife, and other forks to the left of the dinner fork in order of their use, with a sequence from outside in toward the plate. The exception to this rule is the oyster fork, which is placed to the extreme right. In family service, silver for the entire meal may be placed on the table when the covers are laid.

The napkin, folded in a square or a rectangle, may be placed at the left of the fork or in the center of the cover, with loose edges up. The hem and the selvaige should be parallel with the fork and the edge of the table, when the first mentioned position is used.

The water glass is placed at the point of the dinner knife. The bread and butter plate is placed at the tip of the dinner fork, with the butter spreader across the plate, handle to the right, at right angles with the fork. When a salad is served with the main course, the salad plate is placed to the left of the luncheon or the dinner plate.

Salts and peppers may be placed between each two covers,

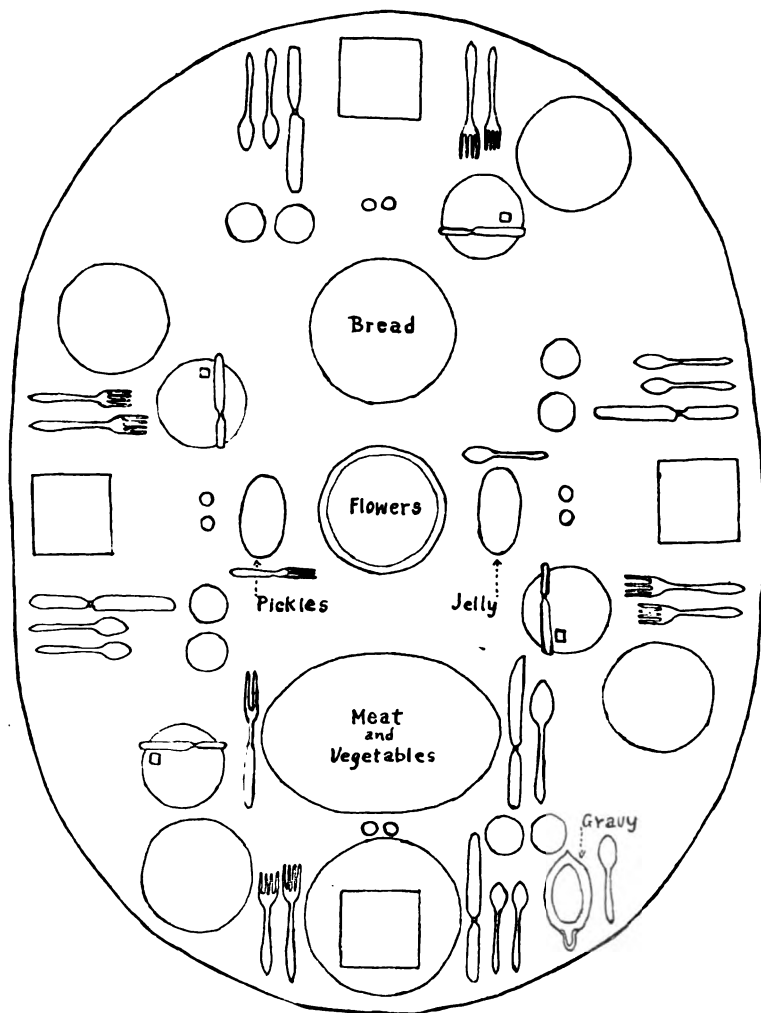


INDIVIDUAL COVER FOR LUNCHEON

- |                       |                           |                     |
|-----------------------|---------------------------|---------------------|
| 1. Plate              | 5. Luncheon Fork          | 9. Butter           |
|                       | (Used also for salad)     |                     |
| 2. Knife              | 6. Napkin                 | 10. Butter Spreader |
| 3. Tea Spoons         | 7. Salad Plate            | 11. Salt and Pepper |
| 4. Tea Cup and Saucer | 8. Bread and Butter Plate | 12. Water Glass     |



or directly in front of each cover when individual containers are used. Place cards may go on the napkin, in front of the cover, or near the goblet.



THE FAMILY DINNER TABLE

In family service, the luncheon or the dinner plates are stacked in front of the host who serves the main dishes. A platter containing the meat and vegetables is placed on a carving cloth in front of the host's cover. The serving silver is laid by the sides of the platter, with the knife and spoons on the

right, and the fork on the left. The gravy bowl goes to the right, with the gravy ladle by its side.

The coffee-pot, or teapot, with cups for serving, is placed to the right of the hostess, and the saucers, cream, and sugar in front of her.

All other foods on the table should be conveniently and symmetrically placed so that the lines will be parallel with the edges of the table, and the table as a whole will look well balanced. When a food is to be passed at the table, the serving silver should be placed beside the dish containing the food.

Dishes to be used for hot food should be heated, and those to be used for cold food should be chilled.

**Types of Service.**—The English or family-type service is best suited to the average family where there is no help. In this service, all food is served at the table by the host and hostess instead of being brought from the kitchen in individual portions.

In the Russian or formal service, the food is served from the kitchen, with the host and hostess taking no part in the service. It may be served on the plates in individual portions or be passed on platters for each person to help himself. In most homes, this service is used only for special parties when outside help can be secured.

The compromise service is a combination of the formal and informal services. According to this type, the main course is served at the table, while the soup, salad, and dessert are served from the kitchen. A family having a maid to aid in the service of meals can afford to use this type.

Most of the early authorities on table service used what is known as right hand service. According to this form, dishes are placed and removed from the right with the right hand, and served from the left with the left hand. Later authorities are now advocating the left hand service, according to which all dishes are placed, passed, and removed from the left with the left hand, except the beverage which is served and removed from the right with the right hand. The left hand service is thought by those who use it to be the simpler, since it contains fewer points to be remembered. Either form, however, is correct provided it is consistently carried out.

**General Rules for Serving.**—All table service should be done quietly, without the appearance of haste. When hired help cannot be employed, a member of the family, either the hostess, a daughter, or a son, may leave the table and perform the duties of a waitress. In this case, all unnecessary form and display should be abolished, in order that too much time may not be spent in the process of removing and placing food and dishes.

Before a meal is announced, everything should be in readiness for the first course. The water glasses are filled three-

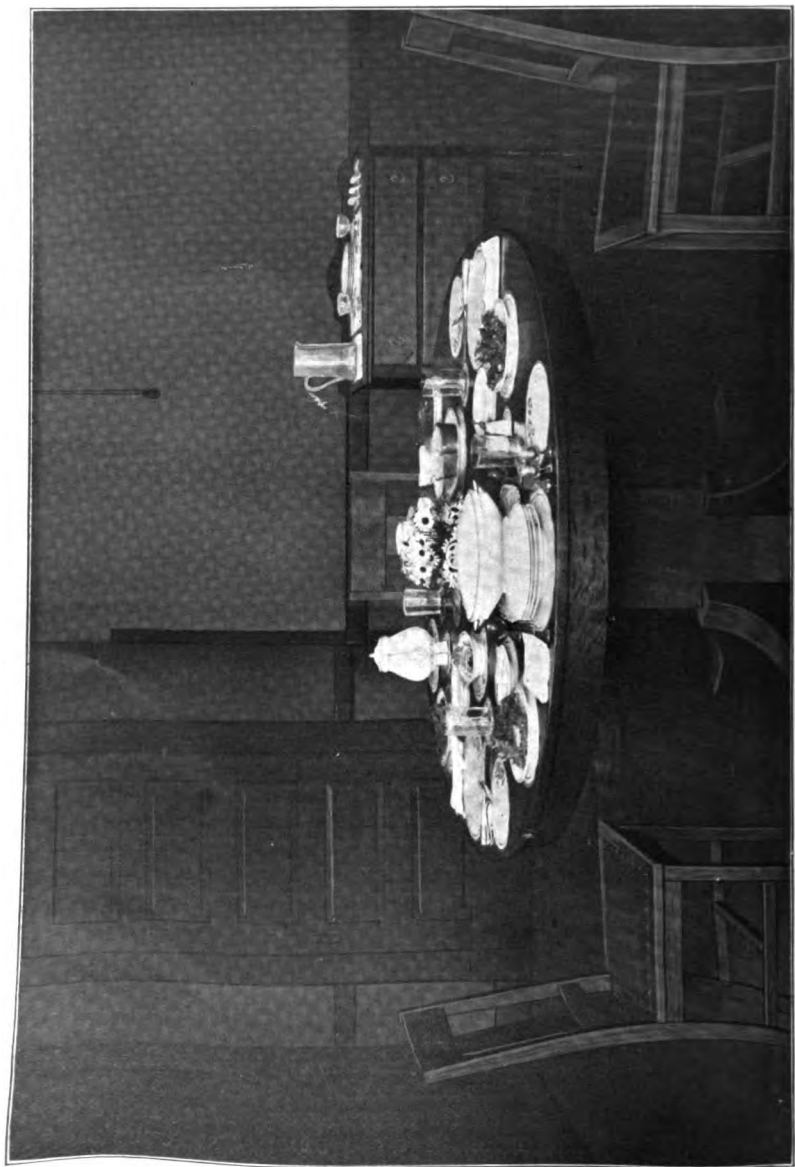


TABLE SET FOR FAMILY LUNCHEON

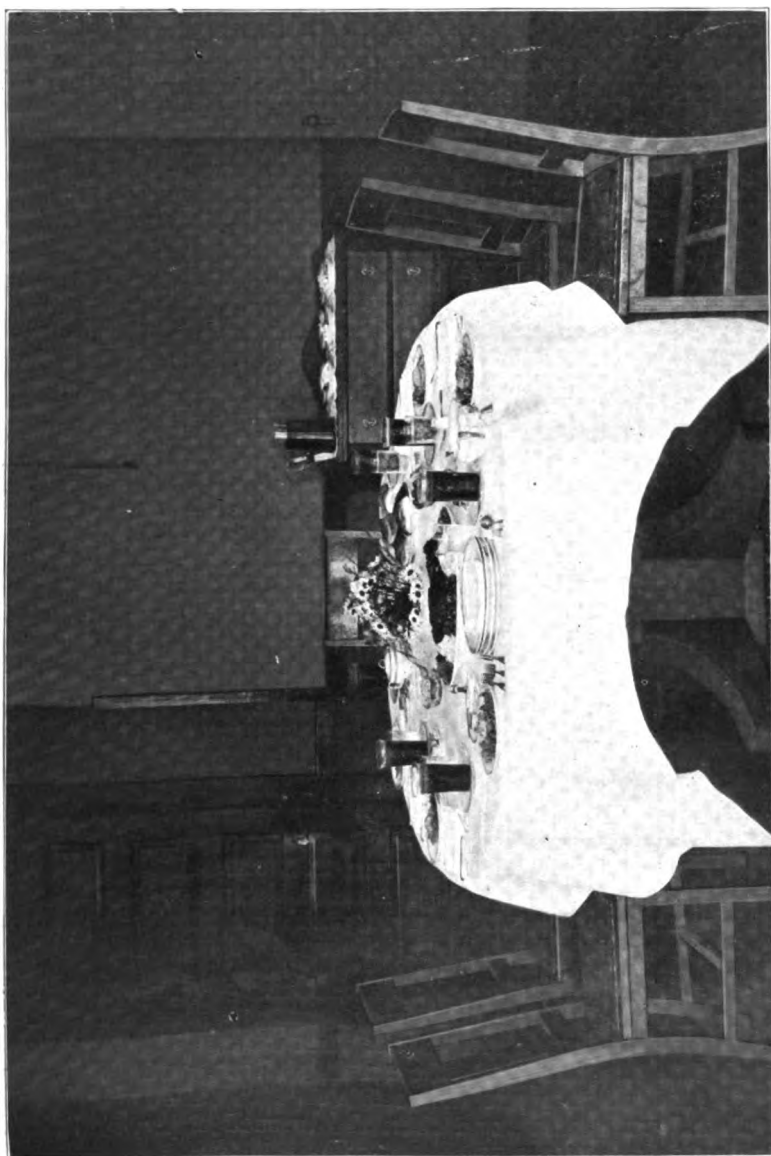


TABLE SET FOR FAMILY DINNER

fourths full, after which the water pitcher is placed on the serving table for further use when needed.

The host serves the meat, vegetables, and gravy of the first course. He may serve the dessert at the table when it is not to be served from the kitchen or serving table. The hostess may serve the salad at the table, or it may be on the table in individual portions when the meal is announced. She usually serves the coffee or tea at the table.

Either the hostess or the guest-of-honor may be served first. The reason for serving the hostess first is that she may see at once if the food is served as she had planned it, and that the proper silver has been provided.

When the host serves the plates, he asks the person to his left to pass the first plate to the hostess. He then serves in succession the next persons to her right (calling the name each time) until all on one side of the table have been served. Beginning on the other side with the person nearest the hostess, he serves in the same succession ending with his own plate. When the plates have all been served, the hostess asks the person nearest the bread, jelly, or pickles, to please help himself and pass it. It is most convenient to pass such foods to the right.

In serving the coffee, the hostess asks the person to whom the cup is to be passed if he cares for cream and sugar, and how much. According to his wishes, she puts cream or sugar in the cup, pours the coffee, and asks that the cup be passed to the person consulted. She serves first the lady-guest-of-honor, who sits at the right of the host, and then others in succession, until all on her left have been served. She serves the next cup to the host, and then to those on his left in succession, serving herself last.

In offering second helpings of food, the host first asks the hostess if she will be served. She takes a small portion, even though she may not want it, in order that her guests may feel free to accept a second helping when it is offered. When more food such as bread, butter, etc., is needed, the person waiting on the table goes quietly to the serving table or kitchen, gets the food, and places it on the table to be passed.

**Clearing the Table After the Main Course.**—(Left Hand Service). In clearing the table after the main course, one should remove all dishes containing food: first of all, the platter or principal dish together with the serving silver, and then other dishes of food as they are convenient. The soiled plates and silver should come next, and then the unused china and silver pertaining to that course.

When removing covers, the person acting as waitress begins with the hostess and keeps to her right around the table. If the hostess is waiting on the table, she begins with the cover to her

right, and keeps to her right, removing her own cover last.

The waitress stands at the left of the person whose cover is being removed and with her left hand, removes the dinner plate. She transfers this plate to her right hand, takes up the salad plate, and places it on the dinner plate. She next picks up the bread and butter plate and places it on the salad plate. She transfers these plates back to her left hand, goes to the right of the person, and with her right hand removes the beverage cup or glass. She may place this cover on the serving table while another is being removed, in order that the two may be carried together to the kitchen.

After all covers have been removed, the waitress brings a tray or a plate to the table, picks up the salts and peppers, unused silver of the first course, the carving cloth, and extra doilies if the doily service has been used. At the same time, she brushes the crumbs from the table, using a crumb brush or a napkin.

The waitress again fills the water glasses, which have been left on the table, from the right, holding the water pitcher in her right hand. She uses a napkin to catch the drip, and does not, ordinarily, lift the glass from the table while it is being filled. If the covers are crowded, she may take hold of the glass well down toward the bottom and draw it to the edge of the table.

If dessert and coffee are to be served at the table, the waitress places the china or glassware for the dessert in front of the host, and the dessert and serving silver directly beyond the dishes for serving. She places the saucers for the coffee in front of the hostess, the cream and sugar in front of the saucers, and the cups and coffee-pot to her right.

If the dessert is served from the kitchen, it may all be brought in individual portions to the serving table. Most authorities say that only one dish at a time should be brought to the dining table, but time and steps can be saved if one carries two, and then serves them one at a time, from the left with the left hand. The waitress, a member of the family, takes her place at the table and eats with other members of the group, after she has finished serving.

The foregoing description of table service is that of a family dinner, but the same general rules should be observed in serving a breakfast, luncheon, or supper. The main idea to be kept in mind concerning the family-type service, is that it must be done easily and gracefully, with the minimum number of trips to the kitchen.

### SPECIAL OCCASION SERVICE

The woman of today who entertains has the combined duties of chef, waitress, and hostess. Because of this fact, she must entertain simply, yet graciously, attempting only that in which she can excel. The wise hostess has learned that the success of

her meals depends more on her spirit of hospitality, than on the elaborateness of her food preparation. It has been said that a woman who invites guests into her home should have as her ideal, "Excellent cooking, immaculate surroundings, attractive service, individuality, and genuine hospitality".

The forms of entertainment most used at the present time are family meals, buffet luncheons or suppers, formal luncheons, teas, and receptions, depending on the occasion and on the number of people invited. For these occasions help can be hired by the hour, when members of the family are unable or do not care to do all the work themselves. Formal dinners in the home are becoming obsolete, except for the ultra rich, who can afford the proper equipment and servants for such occasions. Most people prefer to do well a simple form of entertainment rather than go beyond their means in a feeble attempt at an elaborate form.

**Family Meals.**—When guests are invited to family meals, the food and service should not be radically different from the usual order. It is far better to serve attractively a few well cooked foods, using the silver, china, and linen, owned by the family, than to attempt an elaborate menu that will make necessary the borrowing of equipment, or the serving of imperfectly prepared foods. Guests are happiest when they are made to feel that no extra work or worry has been caused by their visit.

**The Buffet Luncheon or Supper.**—At a buffet luncheon or supper, an entire course is served on one plate. The guests may stand, sit in chairs around the room, or be seated at small tables arranged for that purpose.

The buffet service may be either informal, semi-formal, or formal. In either case, a menu of two courses is sufficient. If the plate is to be held on the lap, the food served must be such as can be eaten without the aid of a knife. This form of service is especially suitable for large groups of people.

**Informal.**—In informal buffet service, food is placed on the dining table in platters, chafing dishes, or covered dishes, with serving silver in place. The beverage, in a suitable container, is also placed on the table. Napkins, silver, plates, cups, and glasses are arranged in convenient order on the dining table or on the buffet. Each person helps himself to a napkin, plate, silver, cup or glass, and food. After the first course, the dining table is cleared and the plates are stacked on the serving table. The dessert, with suitable dishes and silver for serving, is placed and served in the same manner as the first course. Sunday night suppers may be attractively served in this way.

**Semi-formal.**—For semi-formal service, the food and dishes are placed in the same order as for the informal buffet. Guests



TABLE SET FOR BUFFET LUNCHEON



take their napkins, plates, silver, and cups or glasses, to the dining table where they are served by friends of the hostess who sit at the table. Larger groups of people may be served in this way than can be served according to the informal style.

*Formal.*—At a formal buffet luncheon, the food is arranged on a dining table set with linen, china, and silver. Small tables laid with linen and silver may be provided for the guests, or chairs for them may be arranged around the room. All food is served from the dining room rather than from the kitchen. Friends of the hostess sit at the dining table and serve the main foods, while waitresses carry the plates to the guests, and remove them after the course is finished. Rolls, sandwiches, relishes etc., are passed to the guests by the waitresses. This type of service may be used at wedding breakfasts or luncheons, and at other large gatherings where a whole meal is served.

**The Formal Luncheon.**—The formal luncheon has taken the place of the formal dinner in families of moderate means. When outside help for serving is needed, it is often possible to secure younger friends or high school girls. The hour for the formal luncheon is one o'clock. It is usually a party for women, since men cannot get away from business at this hour. Written invitations may be sent, although the telephone has become a popular medium for extending invitations.

The luncheon offers a great opportunity for the hostess to exercise her skill and originality. At this time, she uses her best linen, china, and silver. One large table, is set with a luncheon cloth, or a doily set, on the bare polished surface. Flowers in the center decorate the table, but candles should be used only when artificial light is needed. Color schemes, which play an important part in the success of the meal, may be carried out in flowers, place cards, food, and frocks worn by waitresses.

If a bare table is used, the correct number of plate doilies is placed at equal distances around the table, with a service plate on each doily. Silver for the entire meal is laid unless it makes too great a display. In this case, the part needed for the last course is laid just before the course is served. The water glass, in its usual position, is put on the table at the beginning of the meal. Bread and butter plates may or may not be used. If they are used, they may be on the table with the first course, or brought on at the beginning of the second. All doilies go on and off the table, with the dishes under which they are placed. Salts and peppers are put on small doilies between each two covers, while nut cups are placed in front of the plates. If favors are used, they may be placed on the napkins, in front of the plates, or in groups around the center-piece with ribbons leading to each plate. Candy and nut dishes, with a doily under each, go on the table at the beginning and remain throughout

the meal. Filled cocktail glasses, on small plates fitted with doilies, are placed on the service plates when luncheon is announced.

The formal luncheon may be served in either three or four courses. A three course luncheon consists of a cocktail, a main course with a salad, and a dessert with coffee, nuts, and candy. In a four course luncheon, the salad is served as a separate course. All dishes served should be dainty and attractive.

After the first course, the waitress, beginning with the hostess, removes the cocktail glass with the small plate, from the left with her left hand, to the serving table. In the same manner, she removes the cover of the person who sits to the right of the hostess, and carries the two to the kitchen. Keeping to the right of the hostess, she removes the other covers in succession, making one trip to the kitchen for each two covers.

The second course may be served on plates in the kitchen, or it may be passed on platters for guests to help themselves. The waitress removes the service plate from the left, with her right hand, and places the luncheon plate from the left, with her left hand. She places the doily, and then the salad plate containing the salad, to the left of the luncheon plate. She serves all food except the beverage from the left with her left hand. Food passed on a platter should be held low enough for the person being served to reach it with ease. A waitress should hold a folded napkin under any dish containing food.

The table is cleared for the dessert course according to the rules for family service. All doilies are removed except the ones under the luncheon plates. Doilies for the coffee cups are brought to the table on a tray and placed to the right of each cover. The dessert is served from the left with the left hand, while the coffee is served from the right with the right hand. Nuts and candy may be passed at the table.

Individual finger bowls may be placed in front of the dessert plates, slightly to the left, or they may be brought in after the dessert plates have been removed. They should contain tepid water and may be garnished with a few petals or leaves from the flowers used in decorations.

**Teas.**—There are two types of teas, the small informal tea to which only a few friends are invited, and the formal afternoon tea, used to entertain a large number of people. A tea is an acceptable way to present a guest or to entertain for a debutante. Invitations are verbal for an informal and written for a formal tea. An invitation to a formal tea does not require an answer. When a person cannot attend, formal custom demands that he send his card to the hostess on the day of the tea.

*Informal.*—At an informal tea, the hostess usually serves

such foods as sandwiches, wafers, and tea, to one or more friends. The tea wagon may be used, in which case it should be made ready before hand, with napkins, silver, china, sandwiches, wafers, lemons, sugar, and a teapot with hot water. This being done, the hostess may serve her guests without spending much time in the kitchen.

*Formal.*—At a formal tea, the hostess greets the guests as they arrive and presents the guest-of-honor. A friend of the hostess invites the guests to be served in the dining room where there may be vocal or instrumental music. Guests should stay from fifteen to thirty minutes and need not take leave of the hostess on departing. Formal tea hours are from three to six in the afternoon.

The dining table should display the greatest skill of the hostess. A luncheon cloth may be used, but doilies on a polished surface are more pleasing. Food, silver, china, and glassware are placed as for formal buffet service, although napkins need not be used. Two or more friends of the hostess "pour", while waitresses, usually young girls, carry the plates to the guests and collect them after the course has been finished. Maids may be in attendance to carry used dishes to the kitchen, bring in fresh dishes, and replenish food dishes.

*Receptions.*—A reception is like a formal tea except that more people are invited, and a longer receiving line greets the guests at the door. Because of the large crowd, refreshments are served in one course, and may be lighter than are usually served at a tea.

*Wedding Meals.*—At a wedding, the food and its service may be simple or elaborate, depending on the finances and the desires of the bride's family. In either case, definite plans should be made, and sufficient help should be secured to relieve the bride and her mother of this responsibility. The wedding day should be considered a time for visiting rather than a time for feasting.

*Breakfasts.*—A breakfast, served any time between nine and twelve o'clock, may be informal or formal, depending on the wishes of the bride and on the number of guests invited. The buffet service is especially adapted for such occasions. The menu is very much like that of a luncheon. The salad may be omitted, but a frozen dessert with the bride's cake is considered an essential part of the menu.

*Luncheons.*—If the wedding meal is served at one o'clock, it should be a luncheon, served buffet style or as a formal luncheon. The menu should be planned to include the bride's cake, which is cut by the bride and passed to the guests.

*Receptions.*—A wedding reception may be held in the afternoon between the hours of three and six o'clock. For this occasion, the menu and service are the same as for a formal tea.

*Dinners.*—Six o'clock is the dinner hour for family-type service, while eight o'clock is the usual hour for formal dinners. Any food served after eight o'clock in the evening should be in the form of light refreshments.



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UNIVERSITY OF ARKANSAS

COLLEGE OF AGRICULTURE

# Agricultural Experiment Station

IN CO-OPERATION WITH

BUREAU OF ENTOMOLOGY

U. S. DEPARTMENT OF AGRICULTURE

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## LIFE HISTORY OF THE CODLING MOTH IN ARKANSAS

WITH SPECIAL REFERENCE TO  
FACTORS LIMITING ABUNDANCE

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BULLETIN NO. 189

FAYETTEVILLE, ARKANSAS

DECEMBER, 1923

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# LIFE HISTORY OF THE CODLING MOTH IN ARKANSAS

## With Special Reference to Factors Limiting Abundance

DWIGHT ISELY\* and A. J. ACKERMAN†.

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### INTRODUCTION

The control of the codling moth‡ is probably the most serious problem with which the fruit grower in northwestern Arkansas must contend. Measures taken for control are one of the most expensive of orchard operations, while the results obtained by growers are often unsatisfactory and the annual losses are large. If remedial measures are to be effectively and economically applied, a thorough knowledge of the life history and seasonal activity of the codling moth is imperative. Its seasonal history in the apple region of northwestern Arkansas differs in certain respects, such as the development of as many as four generations a year, from that in most other regions, and has given the apple grower of this region a problem peculiarly his own.

In order to study the codling moth and other insect problems in this region, the Office of Fruit Insect Investigations, Bureau of Entomology, established a laboratory at Bentonville, Ark., in the fall of 1917. The usual studies of seasonal history and duration of stages of the codling moth were carried on throughout the

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‡*Carpocapsa pomonella*; order, Lepidoptera, family Eucosmidae.



seasons of 1918, 1919, and 1921.\* Particular attention was given to oviposition and the factors, temperature and light, limiting it. An effort was made to learn the reason for the differences which occur in local and seasonal abundance of the codling moth and also to determine a method of forecasting the time of hatching of first-brood larvae by which the grower might become less dependent on professional aid. This paper is simply a report of these investigations. No attempt is made to review the work of others.

Spraying experiments have been conducted each year in connection with the life history studies. They are not discussed in this paper,† but a brief statement of recommendations for control is appended.

### ECONOMIC IMPORTANCE OF THE CODLING MOTH

The potential destructiveness of the codling moth in Arkansas is shown approximately by the percentage of infested fruit on unsprayed trees in check plats in orchards where spraying experiments were conducted. In 1918, approximately 73 per cent of the apples on the unsprayed trees were infested. In 1919, a year when the infestation was generally less severe, only 47 per cent of the fruit on the check trees was "wormy". In 1920, 93 per cent of the unsprayed fruit was "wormy". These percentages do not indicate the full severity of the infestation, for in making counts all of the fruit which dropped, as well as the fruit which was harvested was included. Some of the fruit which dropped early in the season, due to apple scab and other causes, did not have time to become infested with codling moth. Practically 100 per cent of the fruit which fell late in the season and that which was harvested was infested. In addition, more than one "worm" to each apple was the rule rather than otherwise.

In 1921 a killing frost in April caused a complete failure of the apple crop and hence there is no record of codling moth dam-

\*These studies were carried on under the general direction of A. L. Quaintance, Entomologist in charge of Fruit Insect Investigations. F. L. Wellman and Byron E. Johnson assisted in the routine work, the former during the seasons of 1918, 1919, and 1920, and Mr. Johnson during 1921. Throughout the greater part of these studies the writers were associated with Leslie Pierce, of the Bureau of Plant Industry, to whom thanks are due for co-operation in many ways. W. J. Baerg, Entomologist of the Arkansas Experiment Station furnished some distribution data and prepared three of the illustrations. The junior writer was transferred for work in California during the season of 1921.

A previous study of the codling moth in the Ozarks was made during the seasons of 1907 and 1908 at Siloam Springs, Ark., by E. L. Jenne of the Bureau of Entomology. This work has been reported in Bureau of Entomology Bulletin 80, part 1.

†For a preliminary report on life history and control see: Isely, Dwight and Ackerman, A. J.—Some features of the codling moth problem in the Ozarks. Journal of Economic Entomology, V. 13, pp. 159-166, 1920.

age for that season. In fact, it was probably starved out in most of the apple orchards. The following year the infestation was relatively light. In 1923, however, losses due to the codling moth were again fully as severe as in 1918 or 1920, showing how rapidly it can be reestablished. It is true that no reinfestation has yet appeared in a few orchards.

Losses suffered in sprayed orchards are variable. In 1919, a year of relatively light infestation, most of the growers were able to control the codling moth satisfactorily. Nevertheless, in several commercial orchards during 1918, 1920, and 1923, 50 to 75 per cent of the apples harvested were "wormy". To estimate the average annual loss at 25 per cent would be conservative.

## SYNOPSIS OF LIFE HISTORY AND SEASONAL HISTORY

### DESCRIPTION OF STAGES

The codling moth, like all other insects of the order Lepidoptera (moths and butterflies) during its life passes through four distinct stages,—the egg, the larva, the pupa, and the adult or parent moth. (See Plate 1.)

The egg of the codling moth is flattened oval in shape, and about the size of a pinhead, the shorter diameter being about 1 mm. and the longer about 1.25 mm. The eggs are deposited singly, glued tightly to the foliage or fruit, and appear as a glistening white spot.

It is only in the larval stage that the codling moth causes injury. When full grown, the larva measures about  $\frac{3}{4}$  inch in length; the body color varies from a pinkish flesh color to white. The head and thoracic shield are dark brown. It has three pairs of well developed thoracic legs and five pairs of fleshy abdominal legs or pro-legs. When full grown the larva spins a cocoon under a piece of bark or in some suitable hiding place, where it transforms to the pupal stage.

The pupa is about  $\frac{1}{2}$  inch long, and varies in color according to age from yellow to brown. The abdominal segments, except the first and last two, are armed each with two rows of backward pointed, short, stout spines. On the last two segments there is but one row of spines.

The adult codling moth is variable in size, although the wing expanse never exceeds  $\frac{3}{4}$  of an inch and is usually much less. The wings are of a brownish gray color and are crossed with dark lines. Near the tip is a brownish colored spot in which are two irregular lines of a coppery or golden color. The hind wings are grayish brown above, darker toward the margin, which bears a delicate fringe. The color of the moth when at rest on the trunk of a tree so harmonizes with the color of the bark that it is not readily seen.

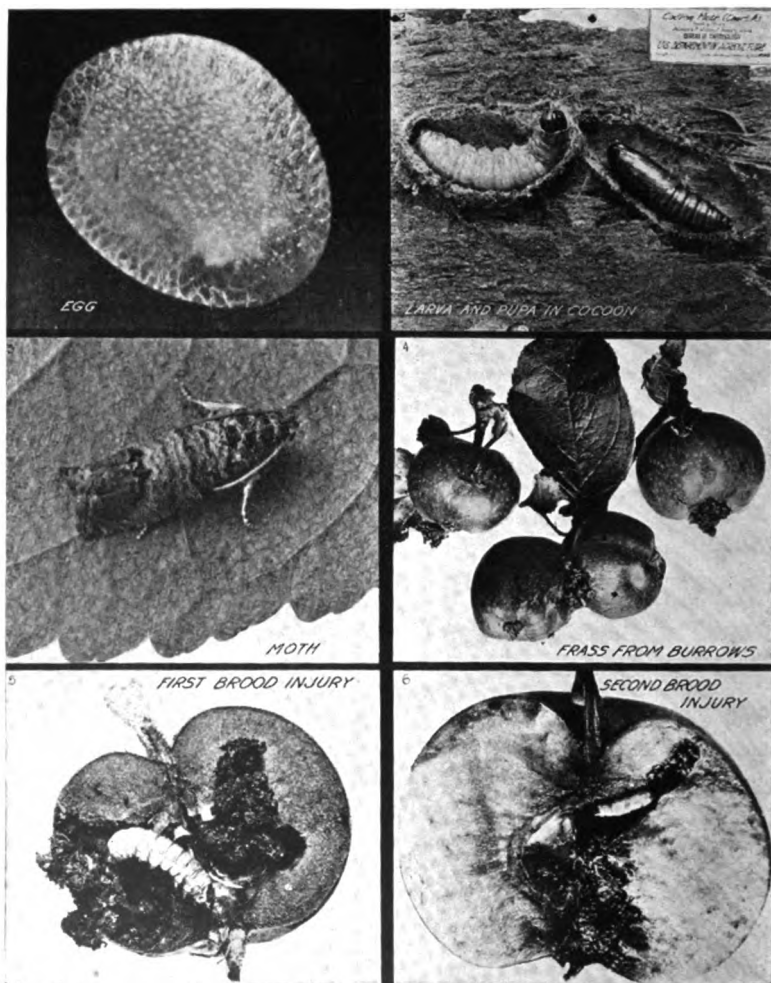


PLATE 1.—Life history of the codling moth, showing stages and injury to fruit.

## SEASONAL HISTORY

The codling moth passes the winter as a larva in a cocoon. In early spring it transforms to the pupal stage and about a month later moths emerge from the cocoons and deposit eggs, giving rise to a new generation. The number of generations apparently depends very largely on the length of the growing season.

## REGIONAL VARIATIONS

The codling moth problem in many respects is a regional problem, since its seasonal history differs in certain respects in each of the apple-producing regions of the United States. For this reason studies of the codling moth made in other parts of the United States cannot apply, in some essential respects, to Arkansas. The most outstanding difference is in the number of generations, which depends largely upon the length of the growing season. At Winthrop\*, Maine, for example, there is but one full generation and a trace of a second, annually, while at Winchester and Charlottesville, Virginia†, there are nearly two full generations. In the Grand Valley of Colorado‡ there are two full generations and a trace of a third. In the Pecos Valley in New Mexico|| there are three generations and a partial fourth. The Ozark fruit region is one of the most southern apple producing regions and the number of generations most nearly resembles the Pecos Valley in New Mexico. In the Ozarks the seasonal history is more erratic than in most of the other fruit regions, due perhaps, to its inland situation and distance from large bodies of water, which produce an equalizing effect upon temperature. The time required to pass through the various stages as well as the fecundity and destructiveness of the codling moth, also vary in the different parts of the United States.

## WEATHER DURING PERIOD OF INVESTIGATIONS

The four seasons during which the work covered by this bulletin was done probably represent fairly well climatic conditions that may be expected in this part of the Ozarks.

**1918.**—The factors relating to codling moth development in the season of 1918 were a moderately early spring, a warm May, a hot dry summer, particularly in June and August, and an un-

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\*Siegler, E. H. and Simanton, F. L. Life history of the codling moth in Maine. U. S. Dept. Agr. Bul. 252, p. 49. 1915.

†Brooks, F. E. and Blakeslee, E. B. Studies of the codling moth in the Central Appalachian Region. U. S. Dept. Agr. Bul. 189, p. 42. 1915.

‡Siegler, E. H. and Plank, H. K. Life history of the codling moth in the Grand Valley of Colorado. U. S. Dept. Agr. Bul. 932, p. 112. 1921.

||Quaintance, A. L. and Geyer, E. W. Life history of the codling moth in the Pecos Valley, New Mexico. U. S. Dept. Agr. Bul. 429, p. 87. 1917.

usually early ripening of the apple crop. The blooming period of Ben Davis (the standard apple variety for the region) was at its height April 7. Petals had fallen so that the calyx spray might be begun by April 18. The harvest of the Ben Davis crop began about September 15.

**1919.**—The spring of 1919 began with a warm period in April immediately after apple blooming, which started an early emergence of codling moths, and a relatively cold May followed. The summer was about the average. The period of Ben Davis bloom was at its height April 15, the calyx spray was begun April 22, and harvest was begun about September 25.

**1920.**—The season of 1920 was similar to that of 1919 in the foregoing features, except that the warm period following petal fall in April did not occur, and May was nearly as warm as in 1918. Ben Davis blooming was at its height April 18, the calyx spray was begun April 23, and harvest was begun about September 25.

**1921.**—The season of 1921 began very early, Ben Davis being in full bloom by March 27. Following this there was much cold weather and a succession of frosts, which killed the commercial apple crop. Warm weather began in May and continued until late in September, although the extreme temperatures of 1918 were not attained.

Table 1 gives a summary of the mean temperatures from April to September for the four years.

TABLE 1.—MEAN TEMPERATURES BY MONTHS\*, DURING THE GROWING SEASON, FOR THE YEARS 1918, 1919, 1920, AND 1921, BENTONVILLE, ARK.

| Year | April | May  | June | July | August | September |
|------|-------|------|------|------|--------|-----------|
|      | °F.   | °F.  | °F.  | °F.  | °F.    | °F.       |
| 1918 | 53.7  | 69.4 | 77.4 | 76.4 | 80.8   | 62.8      |
| 1919 | 57.9  | 63.2 | 73.1 | 78.6 | 77.5   | 71.4      |
| 1920 | 54.4  | 67.4 | 71.6 | 76.6 | 73.5   | 70.6      |
| 1921 | 56.6  | 66.7 | 75   | 79   | 78.4   | 76.2      |

\*Compiled from Climatological Data, Arkansas Section, published by the U. S. Weather Bureau.

## INSECTARY METHODS

The life-history data given herewith are based on rearing records taken in the usual type of screen-sided insectary (Plate 2), and were checked up as far as possible by field observations. Battery jars were used for moth emergence, oviposition, and

rearing of the larval and pupal stages. Larvae were allowed to spin cocoons in the standard "pupa sticks", and jelly tumblers were used for incubation. Oviposition from which incubation records were to be made was secured on pieces of dry twigs, short enough to go into jelly tumblers conveniently. Paper was substituted for cheesecloth in making covers for battery jars when it was desired to prevent evaporation. All larvae upon which records of the overwintering brood were based were collected in the fall. (See Plate 3.)

The number of individuals used to determine the duration or the time of occurrence of any stage was made to correspond, as far as possible, with the degree of variation to be expected and the economic importance of the phenomena in question.

Records were taken daily in most instances. However, in many of the tables in the following text, the records have been grouped into 5-day or 10-day periods for the sake of brevity.

The special rearing methods used in securing oviposition data will be discussed under that head.

## SEASONAL HISTORY

### NUMBER OF LARVAL BROODS IN A SEASON

In the Ozarks three broods of larvae develop each season and in some years a small fourth brood occurs. As will be noted below, some larvae of the first, second and third broods do not transform during the current season, thus reducing the numerical abundance of the second, third, and fourth broods.

In 1918, 2.6 per cent of the first-brood larvae did not transform and went into winter as larvae. Of the second-brood larvae, 17.3 per cent went into hibernation without transforming. Spinning of cocoons by third-brood larvae began August 24. Of the third-brood larvae which cocooned between this date and September 1, 43.17 per cent transformed to the adult stage. No larvae spinning cocoons after this date transformed. These represented a total of 11.1 per cent of the third-brood larvae for which we had cocoon records.

No further attention was given to the exact percentage of larvae of each brood which went into hibernation, until 1921. In that year only first-brood larvae were reared. Of these, 3.36 per cent were apparently single-brooded.

The occurrence of four broods of larvae was recorded only in 1918. In 1919 only three broods were reared. In 1920 and 1921 no line breeding was carried on, as was done in the two previous seasons, and hence the exact number of broods was not established. Jenne\* reared only three broods in the seasons of 1907 and 1908.

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\*Jenne, E. L. The codling moth in the Ozarks. U. S. Dept. Agr. Bur. Ent. Bul. 80, pt. 1, p. 17-19.



PLATE 2A.—Insectary of the U. S. Bureau of Entomology at Bentonville.

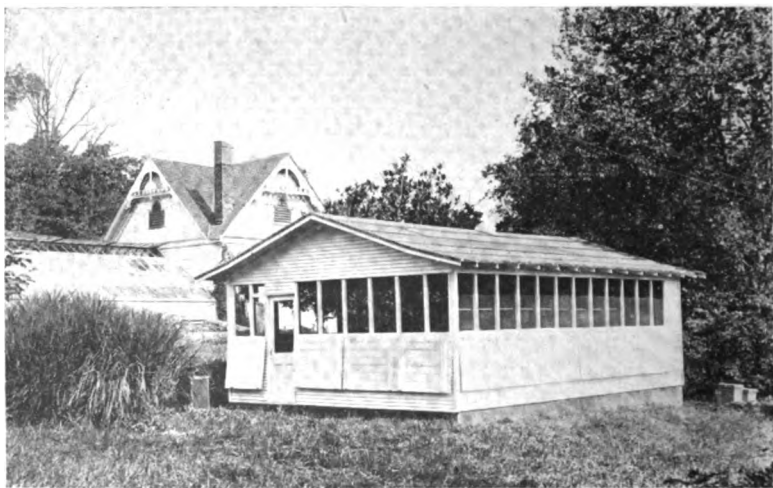


PLATE 2B.—Insectary of the Arkansas Agricultural Experiment Station at Fayetteville.

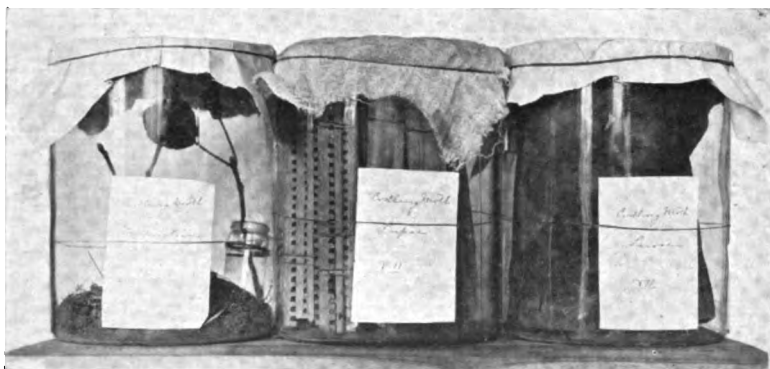


PLATE 3A.—Battery jars used as rearing cages.

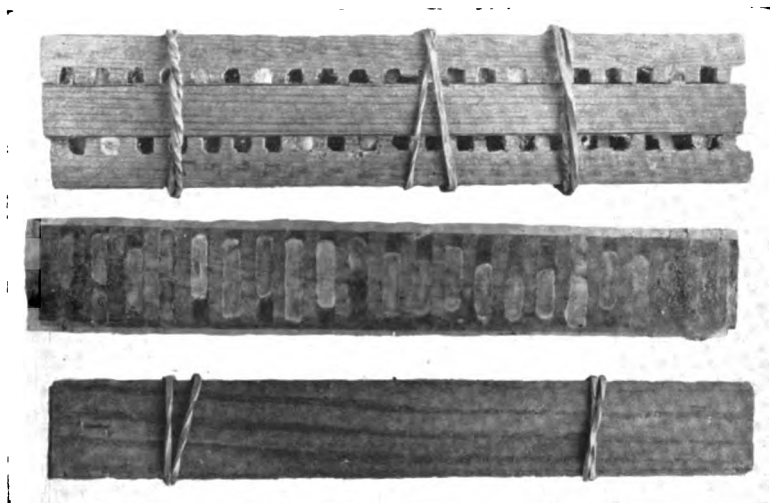


PLATE 3B.—Pupation sticks.



Although four broods of larvae have been found, infestation of the fruit takes place only during two well defined periods. The first period is during the hatching of first-brood larvae and the second is during the hatching of larvae of the second, third, and fourth broods, which overlap to such an extent that it is impossible to make any distinction between them in the field. This second period of infestation is, of course, very much longer than if it included only a single brood. The actual number of broods is of practical importance in that the extra number gives a much greater opportunity for multiplication than if there were only two broods.

The importance of the one-brooded and two-brooded individuals was shown in 1921. During that season the commercial crop of the entire section was killed by spring frosts. However, a few apples were left in some orchards. Practically all of these apples dropped by midsummer, owing to the excessively high infestation of the codling moth and as a result, larvae of later broods had little opportunity to develop. In these orchards the one-brooded and two-brooded individuals enabled the species to maintain itself.

In discussing seasonal history, the spring brood moths and first-brood larvae will be considered together. Moths and larvae of the following broods will be treated in the same manner.

## SPRING PERIOD OF INFESTATION

### PUPATION OF OVERWINTERING LARVAE

The primary economic interest in the time of pupation of the overwintering larvae is that it serves, to some degree, at least, as an indicator of the time of emergence of adults. In the Ozarks the earliest pupation precedes the earliest emergence about a month. The interval between pupation and emergence decreases rapidly as the season advances (as is shown in the tables on the duration of the pupal stage) until the pupal stage of the last individuals of the overwintering brood is no longer than that of the early individuals of the first brood.

Pupation of the overwintering larvae began, in both 1918 and 1919, on March 27, and in 1920 on March 31. It continued for about two months, during each year, our latest records being May 23 for 1918 and May 31 for 1919 and 1920. The increase and decline of numbers of larvae pupating is shown in summarized form in Table 7, discussed under "Duration of Stages". In 1918, pupation was at its height during the first 10 days of April, the greatest number of records being made April 8; in 1919, during the last 10 days of April, and in 1920, the first 10 days of May.

No complete records of pupation were taken for the overwintering larvae in 1921. It began much earlier than in the previous years, however, the earliest date of pupation recorded be-

ing March 13. The latest record was taken June 29. This was an aberrant individual, as pupation practically ceased June 4. The season of 1921 was rather abnormal in that spring opened early but was much prolonged by periods of cold.

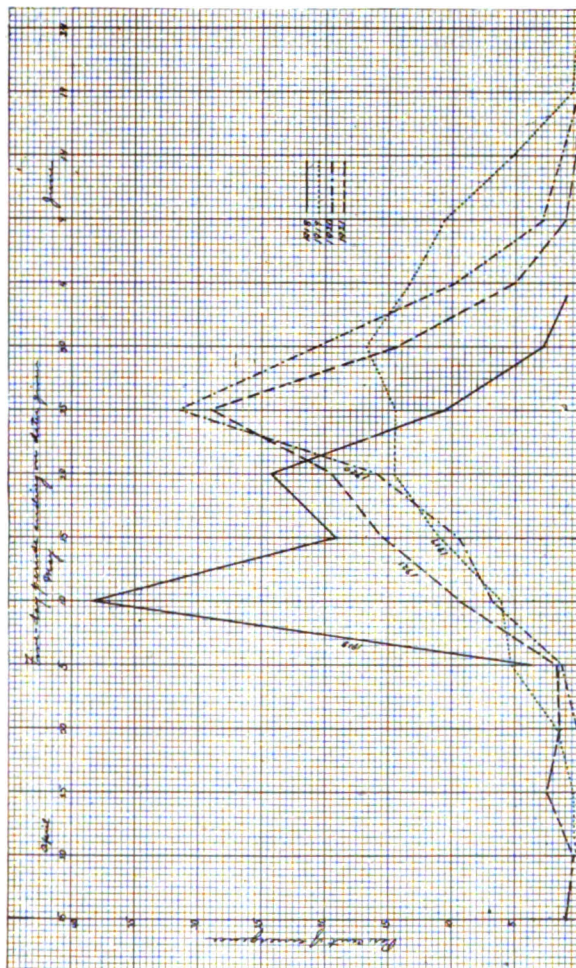


FIG. 1.—Graph showing periods of emergence of moths of the spring generation, for 1918, 1919, 1920, and 1921, Bentonville, Ark.

#### ADULT EMERGENCE

The periods of emergence of moths of the spring brood, for the four seasons during which records were taken, were as follows: 1918, April 29 to June 3; 1919, April 20 to June 23; 1920, April 30 to June 18; and 1921, April 13 to July 13. The records of emergence of spring-brood moths are given in Table 2. The

rise and fall of emergence for 5-day periods is graphically illustrated by Fig. 1. Records of emergence of a total of 7,472 moths were taken during these four years.

It should be noted that the extreme limits given for the period of emergence for each year by no means represent its practical limits. In 1918 the bulk of the brood emerged between May 4 and May 26, a period of about three weeks. In 1919 this period was about twice as long. The bulk of the brood might be said to have emerged between May 1 and June 11, the stragglers outside these limits representing about 5 per cent.

In 1920 the bulk emergence might be said to have extended from May 5 to June 2. During this period, however, the stragglers continued after June 2 in larger numbers than usual, nearly 6 per cent of the moths coming after June 2. The period of emergence was peculiar also, in that, owing to an interval of cold weather, it was divided into two periods, one from May 5 to 13 inclusive and the other from May 18 to June 2.

As previously stated, the season of 1921 was very unusual. The extreme period of emergence of moths actually extended over three months. The early part of the period, however, was frequently interrupted by cold, and regular emergence did not begin until May 6 and practically ceased June 4. An interval of 20 days passed between the emergence of the last moth, July 13, and that of the one immediately preceding it.

#### FIRST-BROOD EGGS

Oviposition by moths of the spring brood does not always promptly follow emergence. In 1918 it followed quite closely, the first eggs being secured in the insectary May 9. Eggs were observed on crab apples in the field as early as May 6, there being an interval of only seven days between this and the earliest date of emergence. By the middle of the month first-brood eggs were being laid in unusually large numbers.

In 1919, on the other hand, a very few eggs were deposited on May 3, 6, and 7, and again a few from May 14 to May 19. No more eggs were secured until May 25, 35 days after the first record of moth emergence and after more than half the brood had emerged. After this time oviposition was regular.

In 1920 the first record of oviposition was taken May 7, and oviposition was scant until May 11. Heavy oviposition did not begin until May 19. In 1921 oviposition was first recorded May 9, and from that time increased gradually.

The seasonal distribution of oviposition by moths of the spring brood can not be shown as completely as that of emergence of moths, for it is obviously difficult to take complete oviposition records for the entire emergence. The approximate distribution of oviposition may be arrived at, however, by multiplying the number of moths emerging in each 10-day period by

TABLE 2.—CARPOCAPSA POMONELLA: EMERGENCE OF THE SPRING BROOD OF MOTHS, BENTONVILLE, ARK.

| Date of emergence | Number of moths | Date of emergence | Number of moths | Date of emergence | Number of moths | Date of emergence | Number of moths | Date of emergence | Number of moths |  |
|-------------------|-----------------|-------------------|-----------------|-------------------|-----------------|-------------------|-----------------|-------------------|-----------------|--|
| 1918              |                 |                   |                 |                   |                 |                   |                 |                   |                 |  |
| April 29          | 1               | May 7             | 38              | May 15            | 52              | May 23            | 24              | May 31            | 2               |  |
| 30                | 1               | 8                 | 99              | 16                | 49              | 24                | 13              | June 1            | 1               |  |
| May 1             | 0               | 9                 | 84              | 17                | 63              | 25                | 13              | 2                 | 4               |  |
| 2                 | 1               | 10                | 83              | 18                | 26              | 26                | 18              | 3                 | 2               |  |
| 3                 | 1               | 11                | 24              | 19                | 65              | 27                | 0               | Total---          | 884             |  |
| 4                 | 10              | 12                | 43              | 20                | 11              | 28                | 2               |                   |                 |  |
| 5                 | 21              | 13                | 4               | 21                | 25              | 29                | 5               |                   |                 |  |
| 6                 | 35              | 14                | 46              | 22                | 18              | 30                | 0               |                   |                 |  |
| 1919              |                 |                   |                 |                   |                 |                   |                 |                   |                 |  |
| April 20          | 1               | May 4             | 16              | May 18            | 68              | May 31            | 96              | June 13           | 17              |  |
| 21                | 0               | 5                 | 18              | 19                | 69              | June 1            | 52              | 14                | 6               |  |
| 22                | 1               | 6                 | 65              | 20                | 12              | 2                 | 50              | 15                | 3               |  |
| 23                | 3               | 7                 | 29              | 21                | 23              | 3                 | 12              | 16                | 4               |  |
| 24                | 3               | 8                 | 6               | 22                | 8               | 4                 | 11              | 17                | 2               |  |
| 25                | 1               | 9                 | 0               | 23                | 69              | 5                 | 34              | 18                | 1               |  |
| 26                | 1               | 10                | 0               | 24                | 116             | 6                 | 32              | 19                | 0               |  |
| 27                | 1               | 11                | 18              | 25                | 24              | 7                 | 46              | 20                | 0               |  |
| 28                | 5               | 12                | 68              | 26                | 56              | 8                 | 28              | 21                | 0               |  |
| 29                | 12              | 13                | 18              | 27                | 48              | 9                 | 35              | 22                | 0               |  |
| 30                | 8               | 14                | 51              | 28                | 57              | 10                | 25              | 23                | 1               |  |
| May 1             | 14              | 15                | 27              | 29                | 57              | 11                | 23              | Total---          | 1661            |  |
| 2                 | 24              | 16                | 58              | 30                | 61              | 12                | 16              |                   |                 |  |
| 3                 | 17              | 17                | 34              |                   |                 |                   |                 |                   |                 |  |
| 1920              |                 |                   |                 |                   |                 |                   |                 |                   |                 |  |
| April 30          | 1               | May 11            | 109             | May 22            | 201             | June 1            | 88              | June 11           | 12              |  |
| May 1             | 0               | 12                | 99              | 23                | 173             | 2                 | 72              | 12                | 5               |  |
| 2                 | 4               | 13                | 63              | 24                | 144             | 3                 | 22              | 13                | 2               |  |
| 3                 | 4               | 14                | 1               | 25                | 164             | 4                 | 14              | 14                | 3               |  |
| 4                 | 7               | 15                | 3               | 26                | 125             | 5                 | 16              | 15                | 1               |  |
| 5                 | 22              | 16                | 7               | 27                | 100             | 6                 | 16              | 16                | 1               |  |
| 6                 | 34              | 17                | 7               | 28                | 155             | 7                 | 17              | 17                | 4               |  |
| 7                 | 29              | 18                | 47              | 29                | 118             | 8                 | 21              | 18                | 4               |  |
| 8                 | 31              | 19                | 169             | 30                | 102             | 9                 | 16              | Total---          | 2909            |  |
| 9                 | 48              | 20                | 235             | 31                | 90              | 10                | 17              |                   |                 |  |
| 10                | 55              | 21                | 231             |                   |                 |                   |                 |                   |                 |  |
| 1921              |                 |                   |                 |                   |                 |                   |                 |                   |                 |  |
| April 13          | 1               | April 27          | 0               | May 11            | 89              | May 25            | 92              | June 7            | 7               |  |
| 14                | 0               | 28                | 0               | 12                | 23              | 26                | 64              | 8                 | 1               |  |
| 15                | 3               | 29                | 26              | 13                | 88              | 27                | 102             | 9                 | 3               |  |
| 16                | 0               | 30                | 2               | 14                | 85              | 28                |                 | 10                | 0               |  |
| 17                | 0               | May 1             | 11              | 15                | 26              | 29                | 81              | 11                | 2               |  |
| 18                | 0               | 2                 | 23              | 16                | 37              | 30                | 43              | 12                | 2               |  |
| 19                | 0               | 3                 | 0               | 17                | 58              | 31                |                 | 13                | 1               |  |
| 20                | 1               | 4                 | 0               | 18                | 68              | June 1            | 28              | 14                | 1               |  |
| 21                | 5               | 5                 | 0               | 19                | 72              | 2                 | 34              | 17                | 1               |  |
| 22                | 2               | 6                 | 22              | 20                | 157             | 3                 | 22              | 22                | 1               |  |
| 23                | 7               | 7                 | 25              | 21                | 101             | 4                 | 20              | July 13           | 1               |  |
| 24                |                 | 8                 | 47              | 22                | 138             | 5                 | 5               | Total---          | 2018            |  |
| 25                | 36              | 9                 | 25              | 23                | 166             | 6                 | 5               |                   |                 |  |
| 26                | 0               | 10                | 70              | 24                | 88              |                   |                 |                   |                 |  |

the average number of eggs deposited by moths emerging during that period (see Table 16). Upon this basis, a hypothetical table has been drawn up, showing the distribution of oviposition of spring-brood moths for the seasons of 1919 and 1921 (Table 3). The time of oviposition for each 10-day group of moths is arbitrarily dated back five days, as this length of time represents about the half-way point in the oviposition period. It will be noted that in this table the bulk of the oviposition is concentrated in a 20-day period.

TABLE 3.—*CARPOCAPSA POMONELLA*: HYPOTHETICAL DISTRIBUTION OF OVIPOSITION OF MOTHS OF THE SPRING BROOD, IN 10-DAY PERIODS, BENTONVILLE, ARK.

| 1919                     |                        |                                         |                                |                                      |
|--------------------------|------------------------|-----------------------------------------|--------------------------------|--------------------------------------|
| Dates included in period | Number of female moths | Average* number of eggs per female moth | Total hypothetical oviposition | Percentage of oviposition per period |
| April 26-May 5-----      | 17                     | 0.50                                    | 9                              | 0.25                                 |
| May 6-May 15-----        | 94                     | 0.79                                    | 74                             | 2.04                                 |
| May 16-May 25-----       | 211                    | 0.88                                    | 185                            | 5.09                                 |
| May 26-June 4-----       | 259                    | 5.28                                    | 1406                           | 38.67                                |
| June 5-June 14-----      | 198                    | 8.88                                    | 1758                           | 48.35                                |
| June 15-June 24-----     | 48                     | 4.26                                    | 204                            | 5.61                                 |
| Total-----               | 827                    |                                         | 3636                           |                                      |
| 1921                     |                        |                                         |                                |                                      |
| April 16-April 25-----   | 3                      | 0.00                                    | 0                              | 0.00                                 |
| April 26-May 5-----      | 39                     | .31                                     | 12                             | .12                                  |
| May 6-May 15-----        | 61                     | 8.17                                    | 498                            | 4.84                                 |
| May 16-May 25-----       | 351                    | 14.63                                   | 5135                           | 50.81                                |
| May 26-June 4-----       | 437                    | 10.21                                   | 4462                           | 44.15                                |
| Total-----               | 892                    |                                         | 10107                          |                                      |

\*See Table 16 for more complete records of oviposition.

†No oviposition records taken for moths emerging in June.

#### HATCHING OF LARVAE

The seasonal distribution of hatching of larvae, or the time when fruit becomes infested, follows the distribution of oviposition with quite dependable regularity. The first hatching usually follows oviposition at an interval of from 8 to 10 days, and toward the end of the season the interval is shortened to 6 or 7 days.

Hatching began in 1918 on May 17; in 1919, on May 11; in 1920, on May 15; in 1921, on May 17. The bulk of hatching in all years was in the latter part of May and early June, although in 1918 and 1921, after hatching had once begun it increased more rapidly than in the other two seasons.

## THE SUMMER GENERATIONS

This discussion of the summer broods begins with the time of maturity of the first-brood larvae, when they leave the fruit and spin their cocoons.

In 1918 the earliest record of the spinning of cocoons by larvae of the first-brood was June 5, although, based on collected pupae, cocooning must have taken place as early as June 2. Moths emerged as early as June 15, and eggs of the second brood were secured June 19. The first of the second brood larvae hatched June 25. By July 1 larvae of the second brood were hatching in considerable numbers. The rapid increase in numbers and the extent of overlapping of the second, third, and fourth broods is shown by Table 4, which summarizes the progress of emergence of moths of the summer broods, and by the accompanying graph (Fig. 2). The broods overlap to such an extent that no distinction between broods, based on emergence of moths from field collected material, can be made.

The beginning of each brood was determined, however, from line breeding. Moths of the second and third broods began emerging July 27 and September 12 respectively, and their offspring, the larvae of the third and fourth broods, began hatching August 4 and September 23 respectively.

Throughout the season a few larvae which did not transform to the pupal stage within a few days after spinning cocoons passed the winter before doing so. The number of non-transforming larvae was small, until the latter part of August, after which practically all of the larvae became wintering individuals. As a matter of fact, no transformations to the pupal stage occurred after August 31. The latest record of oviposition was September 24, and the latest record of hatching of larvae observed in the insectary was September 26. No record of hatching of the last eggs deposited was secured. In orchards, hatching of larvae occurred in large numbers until the middle of September, and then gradually diminished until about October 1.

The summer of 1918 was exceptionally hot and dry and as a result, apple harvest was very early. Jonathan harvest began soon after the middle of August, and most of this variety was harvested by September 1, thus making it impossible for the majority of the late-maturing worms to complete development on this variety. Ben Davis harvest began about September 15, the bulk of the crop being picked by the end of the first week of October.

The second brood of 1919 began slightly later than that of 1918, but ceased activity about the same time. The earliest record of first-brood larvae leaving fruit was June 6, the first moths were secured June 24, the earliest eggs were secured June 27, and the earliest hatching of second-brood larvae was record-



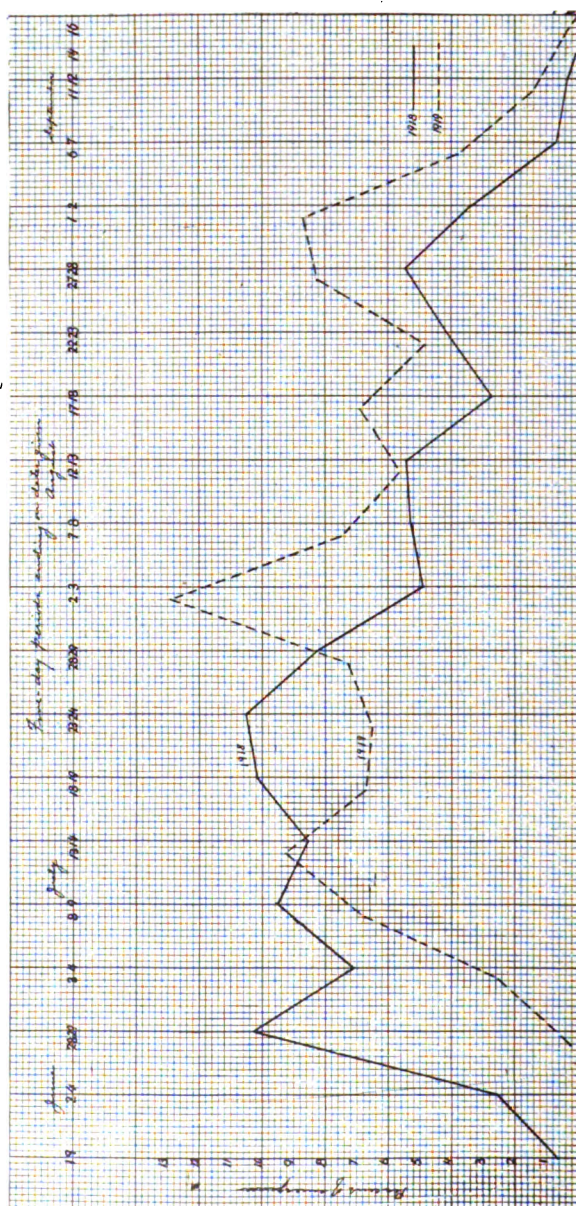


FIG. 2.—Graph showing periods of emergence of moths of the summer generations for 1918 and 1919, Bentonville, Ark.

TABLE 4.—CARPOCAPSA POMONELLA: EMERGENCE OF MOTHS OF THE SUMMER BROODS, BENTONVILLE, ARK.

| First, Second, and Third Broods, 1918. |                 |                    |                 |                    |                 |
|----------------------------------------|-----------------|--------------------|-----------------|--------------------|-----------------|
| Dates of emergence                     | Number of moths | Dates of emergence | Number of moths | Dates of emergence | Number of moths |
| June 15-June 19                        | 17              | July 20-July 24    | 285             | Aug. 24-Aug. 28    | 148             |
| June 20-June 24                        | 70              | July 25-July 29    | 222             | Aug. 29-Sept. 2    | 92              |
| June 25-June 29                        | 278             | July 30-Aug. 3     | 134             | Sept. 3-Sept. 7    | 18              |
| June 30-July 4                         | 194             | Aug. 4-Aug. 8      | 143             | Sept. 8-Sept. 12   | 9               |
| July 5-July 9                          | 258             | Aug. 9-Aug. 13     | 147             | Sept. 13-Sept. 14  | 3               |
| July 10-July 14                        | 232             | Aug. 14-Aug. 18    | 75              |                    |                 |
| July 15-July 19                        | 275             | Aug. 19-Aug. 23    | 113             | Total-----         | 2,713           |
| First and Second Broods, 1919.         |                 |                    |                 |                    |                 |
| June 24-June 28                        | 6               | July 29-Aug. 2     | 313             | Sept. 2-Sept. 6    | 92              |
| June 29-July 3                         | 60              | Aug. 3-Aug. 7      | 182             | Sept. 6-Sept. 11   | 35              |
| July 4-July 8                          | 169             | Aug. 8-Aug. 12     | 137             | Sept. 12-Sept. 16  | 7               |
| July 9-July 13                         | 224             | Aug. 13-Aug. 17    | 167             | Sept. 17           | 1               |
| July 14-July 18                        | 164             | Aug. 18-Aug. 22    | 117             |                    |                 |
| July 19-July 23                        | 158             | Aug. 23-Aug. 27    | 200             | Total-----         | 2,419           |
| July 24-July 28                        | 176             | Aug. 28-Sept. 1    | 211             |                    |                 |

ed July 2. Heavy hatching did not begin until a week later. Emergence of moths of the second brood began August 2 and hatching of larvae of the third brood began August 12. No third brood moths or fourth brood larvae were secured. Table 4 and the accompanying graph (Fig. 2) show, in condensed form, the emergence of the summer brood of moths for this year. The rate of development was somewhat slower than in 1918 and the interval between the second and third broods is quite marked.

The latest records of stages showing cessation of activity for the year are quite similar to those of the previous season. Pupation ceased with the last of August. The record of latest emergence of moths, September 17, was actually later than the previous season. No reliable record of the latest hatching was taken, but it was probably about October 1.

As previously stated, the summer of 1919 was much cooler than that of the preceding year. In relation to apple harvest, codling moth activity ceased earlier, for harvest was about two weeks later. The earliest Jonathans were picked about August 25, but harvest did not seriously begin until about September 1. Correspondingly, Ben Davis harvest was about two weeks later than it had been the preceding season.

In 1920, the earliest moths of the first brood were recorded June 27, the first second-brood eggs were secured July 1, and the first second-brood larvae hatched July 6. Complete records for the remainder of the season were not taken. Fairly heavy hatching of larvae continued until September 15, much later in the season than in 1919.



TABLE 5—CARPOCAPSA POMONELLA: DURATION OF THE INCUBATION PERIOD, BENTONVILLE, ARK., 1918, 1919.

| 1918               |                 |                               |           | 1919         |                    |                 |                               |           |              |
|--------------------|-----------------|-------------------------------|-----------|--------------|--------------------|-----------------|-------------------------------|-----------|--------------|
| Date of deposition | Num-ber of eggs | Duration of incubation period |           |              | Date of deposition | Num-ber of eggs | Duration of incubation period |           |              |
|                    |                 | Min. Days                     | Max. Days | Average Days |                    |                 | Min. Days                     | Max. Days | Average Days |
| May 1 to 10        | 20              | 8                             | 8         | 8.00         | May 1 to 10        | 7               | 10                            | 10        | 10.00        |
| 11 to 20           | 37              | 5                             | 7         | 6.16         | 11 to 20           | 14              | 8                             | 12        | 10.00        |
| 21 to 31           | 136             | 5                             | 6         | 5.63         | 21 to 31           | 65              | 7                             | 8         | 7.63         |
| June 1 to 10       | 120             | 6                             | 7         | 6.12         | June 1 to 10       | 46              | 5                             | 6         | 5.09         |
| 11 to 20           | 4               | 5                             | 5         | 5.00         | 11 to 20           | 95              | 6                             | 6         | 6.00         |
| 21 to 30           | 531             | 4                             | 8         | 5.84         | 21 to 30           | 30              | 5                             | 6         | 5.97         |
| July 1 to 10       | 1,753           | 4                             | 9         | 6.22         | July 1 to 10       | 177             | 5                             | 6         | 5.87         |
| 11 to 20           | 348             | 5                             | 7         | 5.77         | 11 to 20           | 325             | 4                             | 6         | 5.10         |
| 21 to 31           | 406             | 4                             | 6         | 5.07         | 21 to 31           | 266             | 4                             | 6         | 4.89         |
| Aug. 1 to 10       | 257             | 4                             | 6         | 5.11         | Aug. 1 to 10       | 439             | 4                             | 6         | 4.56         |
| 11 to 20           | 308             | 4                             | 6         | 4.77         | 11 to 20           | 133             | 5                             | 6         | 5.58         |
| 21 to 31           | 349             | 5                             | 9         | 6.55         | 21 to 31           | 186             | 5                             | 8         | 6.31         |
| Sept. 1 to 10      | 299             | 8                             | 11        | 9.11         | Sept. 1 to 10      | 28              | 5                             | 6         | 5.68         |
| 11 to 20           | 100             | 7                             | 12        | 9.55         |                    |                 |                               |           |              |

Owing to the failure of the apple crop in 1921, no record extensive enough to be of any value was obtained.

## DURATION OF STAGES

### EGG STAGE

The duration of the egg stage, or the period of incubation, depends largely upon temperature. In our records for 1918 and 1919 the variation is from 4 to 12 days. During the summer months the time required for incubation is the shortest, ranging from 4 to 6 days on the average. Since temperatures are consistently high at this season of the year, there is relatively little variation. It is during the very earliest and the very latest part of the season, when the lowest temperatures are likely to occur, that most time is required. The range of variation is also much greater at this time, making forecasts of the time required for hatching of the earliest first-brood eggs much more difficult than forecasts for any of the succeeding broods.

The seasonal variation for the duration of the incubation period is shown in Table 5.

In order to determine the time required for incubation at a given temperature, more closely than could be done from insectary records, incubation records of lots of eggs were taken in a cellar where the daily variation was usually not more than 2 or 3 degrees. Temperature records were taken with maximum and minimum thermometers. A summary of the records is shown in Table 6.

TABLE 6.—CARPOCAPSA POMONELLA: DURATION OF INCUBATION AND MEAN TEMPERATURE FOR THE PERIOD, BENTON-VILLE, ARK., 1920.

| Date of deposition | Number of larvae hatched | Average duration of incubation period | Mean temperature for period | Date of deposition | Number of larvae hatched | Average duration of incubation period | Mean temperature for period |
|--------------------|--------------------------|---------------------------------------|-----------------------------|--------------------|--------------------------|---------------------------------------|-----------------------------|
|                    |                          | Days                                  | °F.                         |                    |                          | Days                                  | °F.                         |
| Aug. 1             | 47                       | 5.22                                  | 73.17                       | Aug. 20            | 10                       | 7.20                                  | 68.61                       |
| 2                  | 48                       | 6.18                                  | 72.62                       | 21                 | 29                       | 7.04                                  | 68.61                       |
| 4                  | 52                       | 5.69                                  | 72.59                       | 22                 | 42                       | 7.76                                  | 68.87                       |
| 6                  | 52                       | 6.35                                  | 71.84                       | 26                 | 35                       | 8.00                                  | 66.47                       |
| 7                  | 24                       | 6.29                                  | 71.43                       | 29                 | 50                       | 9.46                                  | 65.44                       |
| 8                  | 21                       | 6.00                                  | 70.96                       | 30                 | 52                       | 9.33                                  | 65.46                       |
| 14                 | 18                       | 7.33                                  | 69.71                       |                    |                          |                                       |                             |

It will be noted that the extremes of time required for hatching also represented extremes in temperatures and that roughly an increase in temperature of 2° F. resulted in a decrease of time required for hatching of 1 day.

## LARVAL FEEDING PERIOD

The duration of the larval feeding period, for 1,227 individuals reared in 1918 and 1919, ranged from 11 to 41 days. The seasonal variation in time required for this period is shown in the summary in Table 7. In this table, each season is divided in 10-day periods and all larvae hatched in each period are classed together. It will be noted that the shortest average time for any 10-day period required for the larval feeding stage is 16.06 days, the record for July 21-31, 1918. The longest average time is 31.42 days, for September 1-10, of the same year.

The duration of the larval feeding period is less influenced by changes in temperature than the duration of either of the other immature stages. It is true that larvae which hatch in the early part or the late part of the season require, on the average, more time for development than those hatched in midsummer, but the rate of development does not consistently follow the decline in temperature. Even during midsummer, when the average time required for development was least, there were always some individuals of a group which required nearly as much time as the larvae developing most slowly in the cooler parts of the year. The extreme variation is very great.

It is probable that the failure of the codling moth larva to respond to normal temperature is due to the fact that the temperature inside of an apple is quite different from that of the air, and the temperature of growing apples is probably lower than that of picked fruit in stock jars in the insectary. The variation in time required may be influenced by variation in the quality or food value of the various apples used, the degree of ripeness or decomposition, and the variety in question.

## PERIOD IN THE COCOON

The duration of the period in the cocoon varies greatly. With the summer broods the time required for this period is much shorter, the minimum time recorded being 9 days. On the other hand, since winter is passed in the cocoon, the wintering individuals may pass six to eight months (and in a few instances even longer) in the cocoon. No attempt has been made to keep an accurate record of the entire period spent in the cocoon by the wintering individuals. On the other hand, records have been kept for the period in the cocoon and for the prepupal and pupal stages of the summer broods.

## PUPAL PERIOD OF OVERWINTERING LARVAE

The duration of the pupal stage of the overwintering larvae in 1918, 1919, and 1920, is summarized in Table 8. The extreme limits are shown to range from 12 days to 45 days. It will be noted that the average duration of this stage during each 10-day

TABLE 7.—CARPOCAPSA POMONELLA: DURATION OF LARVAL FEEDING PERIOD, BENTONVILLE, ARK., 1918, 1919.

| 1918                             |                   |                    |           |                | 1919                      |                   |                    |           |                |
|----------------------------------|-------------------|--------------------|-----------|----------------|---------------------------|-------------------|--------------------|-----------|----------------|
| Dates of hatching                | Num-ber of larvae | Duration of period |           |                | Dates of hatching         | Num-ber of larvae | Duration of period |           |                |
|                                  |                   | Min. Days          | Max. Days | Average Days   |                           |                   | Min. Days          | Max. Days | Average Days   |
| May 11 to 20<br>21 to 31         | 9<br>113          | 19<br>16           | 27<br>27  | 20.77<br>18.72 | May 11 to 20<br>21 to 31  | 3<br>22           | 24<br>22           | 27<br>37  | 25.75<br>25.46 |
| June 1 to 10<br>11 to 20         | 42<br>7           | 16<br>13           | 22<br>20  | 18.02<br>16.14 | June 1 to 10<br>11 to 20  | 78<br>56          | 17<br>16           | 32<br>28  | 21.10<br>19.53 |
| 21 to 30                         | 47                | 16                 | 32        | 21.32          | 21 to 30                  | 3                 | 17                 | 20        | 15.67          |
| July 1 to 10<br>11 to 20         | 132<br>107        | 15<br>14           | 37<br>27  | 20.22<br>18.99 | July 1 to 10<br>11 to 20  | 60<br>65          | 16<br>14           | 31<br>26  | 22.58<br>18.24 |
| 21 to 31                         | 96                | 11                 | 31        | 16.06          | 21 to 31                  | 141               | 13                 | 29        | 18.27          |
| Aug. 1 to 10<br>11 to 20         | 47<br>26          | 16<br>18           | 36<br>39  | 22.98<br>27.69 | Aug. 1 to 10<br>11 to 20  | 50<br>16          | 15<br>21           | 38<br>41  | 23.49<br>26.00 |
| 21 to 31                         | 42                | 21                 | 40        | 29.02          | 21 to 31                  | 26                | 21                 | 36        | 26.54          |
| Sept. 1 to 10                    | 12                | 29                 | 35        | 31.42          | Sept. 1 to 10<br>11 to 12 | 22<br>5           | 21<br>21           | 35<br>30  | 27.50<br>25.60 |
| Total number of larvae           |                   |                    |           |                | 1,227                     |                   |                    |           |                |
| Minimum length of feeding period |                   |                    |           |                | 11 days                   |                   |                    |           |                |
| Maximum length of feeding period |                   |                    |           |                | 41 days                   |                   |                    |           |                |



period (except in one case) was progressively shorter as the season advanced. The average time required for the pupal stage of individuals pupating during the last 10 days of May is approximately half that required for those pupating during the last 10 days of March.

#### PERIOD IN THE COCOON, SUMMER GENERATIONS

The duration of the entire period in the cocoon during the summers of 1918 and 1919 is shown in Table 9. The time required varied from 9 to 30 days. The average time required for individuals spinning cocoons in any 10-day period varied only from 13.56 to 20.59 days.

TABLE 9.—*CARPOCAPSA POMONELLA*: DURATION OF ENTIRE PERIOD IN COCOON OF SUMMER GENERATIONS, BENTONVILLE, ARK., 1918, 1919, AND 1921.

| Dates of spinning cocoons | Number of individuals | Duration of period |         |         |
|---------------------------|-----------------------|--------------------|---------|---------|
|                           |                       | Minimum            | Maximum | Average |
|                           |                       | Days               | Days    | Days    |
| 1918                      |                       |                    |         |         |
| June                      | 1 to 10               | 10                 | 23      | 14.32   |
|                           | 11 to 20              | 10                 | 24      | 15.03   |
|                           | 21 to 30              | 11                 | 21      | 15.50   |
| July                      | 1 to 10               | 14                 | 29      | 16.89   |
|                           | 11 to 20              | 11                 | 22      | 14.81   |
|                           | 21 to 31              | 9                  | 24      | 14.64   |
| Aug.                      | 1 to 10               | 9                  | 28      | 14.20   |
|                           | 11 to 20              | 9                  | 27      | 16.77   |
|                           | 21 to 31              | 13                 | 30      | 20.59   |
| 1919                      |                       |                    |         |         |
| June                      | 1 to 10               | 12                 | 20      | 15.27   |
|                           | 11 to 20              | 11                 | 18      | 13.83   |
|                           | 21 to 30              | 11                 | 23      | 13.92   |
| July                      | 1 to 10               | 10                 | 23      | 14.14   |
|                           | 11 to 20              | 10                 | 19      | 14.77   |
|                           | 21 to 31              | 11                 | 18      | 13.56   |
| Aug.                      | 1 to 10               | 10                 | 23      | 14.33   |
|                           | 11 to 20              | 11                 | 22      | 14.97   |
|                           | 21 to 31              | 14                 | 26      | 15.37   |
| 1921                      |                       |                    |         |         |
| July                      | 1 to 10               | 13                 | 23      | 16.50   |
|                           | 11 to 20              | 14                 | 17      | 15.77   |

## PREPUPAL PERIOD

Extensive records for the duration of the prepupal period were taken only in 1919. The extremes of duration were 1 and 8 days. It is possible that the extremely low records are not normal but represent individuals which were disturbed in their cocoons and spun a second or third cocoon. In this way considerable time may have elapsed after feeding had ceased. The average duration for all individuals spinning in any 10-day period in 1919 varied only slightly more than 1 day, ranging from 3.50 to 4.54 days. These data are summarized in Table 10, together with such data as were taken in 1921.

TABLE 10.—*CARPOCAPSA POMONELLA*: DURATION OF PREPUPAL PERIOD OF SUMMER GENERATIONS, BENTONVILLE, ARK., 1919.

(With records for three 10-day periods in 1921.)

| Dates of spinning cocoons | Number of prepupae | Duration of period |         |         |
|---------------------------|--------------------|--------------------|---------|---------|
|                           |                    | Minimum            | Maximum | Average |
|                           |                    | Days               | Days    | Days    |
| 1919                      |                    |                    |         |         |
| June 11 to 20             | 14                 | 2                  | 6       | 3.50    |
| 21 to 30                  | 30                 | 2                  | 6       | 3.50    |
| July 1 to 10              | 61                 | 2                  | 7       | 3.56    |
| 11 to 20                  | 67                 | 2                  | 8       | 4.00    |
| 21 to 31                  | 24                 | 1                  | 7       | 3.96    |
| Aug. 1 to 10              | 175                | 2                  | 8       | 4.14    |
| 11 to 20                  | 310                | 2                  | 9       | 4.54    |
| 21 to 31                  | 54                 | 2                  | 7       | 3.94    |
| 1921                      |                    |                    |         |         |
| June 20 to 30             | 42                 | 3                  | 8       | 5.19    |
| July 1 to 10              | 34                 | 4                  | 9       | 5.12    |
| 11 to 20                  | 16                 | 4                  | 8       | 5.44    |

## PUPAL PERIOD

During the seasons of 1918 and 1919 the extreme limits of the pupal period of the summer broods were 6 and 19 days, but the averages for the various 10-day periods showed a range from 8.75 to 12.26 days only. These data are summarized in Table 11, with data for two periods in 1921.

TABLE 11.—CARPOCAPSA POMONELLA: DURATION OF PUPAL PERIOD OF SUMMER GENERATIONS, BENTONVILLE, ARK., 1918, 1919.

(With records for two 10-day periods in 1921.)

| Dates of spinning cocoons | Number of pupae | Duration of period |         |         |
|---------------------------|-----------------|--------------------|---------|---------|
|                           |                 | Minimum            | Maximum | Average |
|                           |                 | Days               | Days    | Days    |
| 1918                      |                 |                    |         |         |
| June 11 to 20             | 92              | 6                  | 15      | 9.50    |
| 21 to 30                  | 215             | 7                  | 15      | 11.16   |
| July 1 to 10              | 166             | 9                  | 19      | 12.12   |
| 11 to 20                  | 93              | 9                  | 15      | 10.76   |
| 21 to 31                  | 34              | 8                  | 13      | 10.20   |
| Aug. 1 to 10              | 10              | 9                  | 15      | 10.90   |
| 11 to 20                  | 31              | 6                  | 11      | 8.81    |
| 21 to 31                  | 9               | 9                  | 15      | 10.77   |
| 1919                      |                 |                    |         |         |
| June 11 to 20             | 11              | 7                  | 12      | 9.91    |
| 21 to 30                  | 76              | 7                  | 18      | 11.26   |
| July 1 to 10              | 60              | 6                  | 17      | 10.33   |
| 11 to 20                  | 45              | 8                  | 14      | 10.15   |
| 21 to 31                  | 20              | 7                  | 12      | 8.75    |
| Aug. 1 to 10              | 114             | 7                  | 14      | 9.81    |
| 11 to 20                  | 219             | 7                  | 17      | 10.51   |
| 21 to 31                  | 38              | 11                 | 14      | 12.26   |
| 1921                      |                 |                    |         |         |
| July 1 to 10              | 38              | 9                  | 17      | 11.50   |
| 11 to 20                  | 12              | 10                 | 12      | 11.17   |

## LIFE OF MOTHS

The longevity of the adult of the codling moth is, of itself, of relatively little importance, at least if the length of the oviposition period be known. Nevertheless, incidental records were taken of the longevity of 206 moths of both sexes of the spring brood of 1921, as shown in Table 12. These records of longevity were of moths in oviposition cages.

In addition, records of longevity of 20 unmated females were taken about the same time, which showed an average longevity of 15 days and an extreme instance of 28 days.



TABLE 12.—CARPOCAPSA POMONELLA: LONGEVITY OF MATED MOTHS OF THE SPRING BROOD, BENTONVILLE, ARK., 1921.

| Date of emergence | Number of moths | Sex    | Length of life |         |       |
|-------------------|-----------------|--------|----------------|---------|-------|
|                   |                 |        | Minimum        | Maximum | Aver. |
|                   |                 |        | Days           | Days    | Days  |
| May 1 to 10       | 46              | Male   | 7              | 15      | 9.94  |
| May 11 to 20      | 54              | Male   | 4              | 17      | 8.72  |
| May 1 to 10       | 33              | Female | 8              | 17      | 14.88 |
| May 11 to 20      | 53              | Female | 6              | 20      | 11.43 |

## PREOVIPOSITION AND OVIPOSITION PERIODS

While the length of life of the moth may be of little importance, the period before oviposition begins, and the oviposition period itself, are of great importance.

As a general rule, when the temperature is favorable for oviposition, moths begin to deposit eggs in from 1 to 3 days, usually 2 days, after emergence. During midsummer the average is slightly less than 2 days. The period before oviposition is much longer when cold weather prevails. This is particularly noticeable when the early moths of the spring brood are emerging. The preoviposition period in several cages of this brood

TABLE 13.—CARPOCAPSA POMONELLA: DURATION OF PREOVIPOSITION PERIOD, BENTONVILLE, ARK., 1921.

| Number of female moths | Duration of period |
|------------------------|--------------------|
|                        | Days               |
| 2                      | 1                  |
| 8                      | 2                  |
| 1                      | 3                  |
| 2                      | 4                  |
| 13                     | Average 2.23       |

extended over a week, and, in one instance, for 14 days. It is probable that the preoviposition period of the majority of early-emerging moths is so extended that some die without depositing eggs. The length of the period of oviposition, like that of preoviposition, is much affected by temperature.

The absolute length of the preoviposition period can be determined only by egg records from isolated females. The preoviposition period in 13 cages, each containing an isolated pair of moths, taken in July, 1921, is shown in Table 13.

The length of the preoviposition period and that of the oviposition period are much better shown by the number of eggs deposited each day.

The total daily oviposition of 315 pairs of moths of the summer broods for the years 1918 and 1919 is shown in Table 14. Oviposition for 97 moths of the summer brood of 1921 is also given, but records for this group of moths were taken only every other day. It will be noted that in 1918 and 1919 there was some oviposition by at least a few moths the first day after emergence, but that this never exceeded 2.3 per cent, or less than one-fortieth of the total oviposition. It really began the second day after emergence. In 1919 over one-fourth of the total number of eggs were deposited during the second day alone, while during each of the three seasons over one-half the eggs were deposited by the end of the fourth day. The extreme oviposition period might be said to extend over 13 or 14 days after emergence, although over 90 per cent of the eggs had been deposited by the end of the seventh day in 1918 and 1919, and by the end of the eighth day in 1921.

A low temperature which reduces the physiological activity of moths may greatly prolong the oviposition period, as shown in Table 15. This table is a summarized record of the daily oviposition of 440 moths of the spring brood of 1921, kept at three different temperatures. It will be noted that the preoviposition period for each lot was 2 days. For Lot 1, which was kept at normal insectary temperature, the extreme oviposition period extended until the 15th day after emergence. For Lot 2, which was kept at a mean temperature of 66.11° F., the extreme period extended to the 19th day. For Lot 3, which was kept at a temperature of 63.71° F., the extreme period was still longer, extending until the 23rd day after emergence.

#### DURATION OF LIFE CYCLE

No continuous records were kept of individual insects throughout their entire life history. The average duration of the life cycle may be computed by adding the average duration of the various stages. Using the lowest first generation averages for any 10-day period—5 days for hatching, 16 days for the

TABLE 14.—CARPOCAPSA POMONELLA: PERIOD OF OVIPOSITION, SHOWING NUMBER OF EGGS DEPOSITED BY MOTHS IN CAGES EACH DAY AFTER EMERGENCE AND PERCENTAGE OF TOTAL OVIPOSITION FOR EACH DAY, BENTONVILLE, ARK., 1918, 1919, AND 1920.

| Year | Num-<br>ber of<br>female<br>moths | Total<br>number<br>of eggs<br>deposited | Days<br>after<br>emergence | 1   | 2     | 3     | 4     | 5     | 6     | 7   | 8     | 9   | 10  | 11 | 12  | 13 | 14  |
|------|-----------------------------------|-----------------------------------------|----------------------------|-----|-------|-------|-------|-------|-------|-----|-------|-----|-----|----|-----|----|-----|
| 1918 | 237                               | 11,018                                  | Eggs<br>deposited          | 196 | 2,208 | 2,765 | 1,634 | 1,448 | 1,108 | 685 | 492   | 240 | 148 | 64 | 12  | 18 |     |
|      |                                   |                                         | Per cent<br>of total       | 1.8 | 20.0  | 25.1  | 14.8  | 13.1  | 10.1  | 6.2 | 4.5   | 2.1 | 1.3 | .6 | .1  | .2 |     |
| 1919 | 78                                | 3,427                                   | Eggs<br>deposited          | 78  | 864   | 728   | 452   | 424   | 394   | 248 | 188   | 42  | 9   |    |     |    |     |
|      |                                   |                                         | Per cent<br>of total       | 2.3 | 25.2  | 21.2  | 13.2  | 12.4  | 11.5  | 7.2 | 5.5   | 1.2 | .26 |    |     |    |     |
| 1921 | 97                                | 11,780                                  | Eggs<br>deposited          |     | 1,214 |       | 4,737 |       | 3,692 |     | 1,366 |     | 584 |    | 180 |    | 7   |
|      |                                   |                                         | Per cent<br>of total       |     | 10.3  |       | 40.2  |       | 31.4  |     | 11.7  |     | 4.9 |    | 1.5 |    | .06 |

Note 1.—Moths used in securing this data emerged in 1918, between June 25 and August 26, inclusive; in 1919, between July 7 and August 27, inclusive; and in 1921, between July 1 and July 8, inclusive.

Note 2.—In 1921 oviposition records in a few cages were taken only once every two days. Hence records for this year given in this table cover periods of two days instead of one day each.

larval feeding period, 15 days for the period in the cocoon, and 2 days for the preoviposition period—a total of 38 days is required for the low average development from egg to egg. Extreme records may be lower than this. By referring to the seasonal history records for 1918, it will be noted that the period between hatching of first and second brood larvae was exactly 38 days. (See pages 16 and 17.)

Throughout the discussion of duration of stages, frequent attention has been called to the accelerating effect of high temperature on insect development. It is understood, of course, that above the optimum temperature the rate of development is retarded rather than accelerated. This may have occurred during the early part of August, 1918. However, such high temperatures are seldom reached in this region, and the point is of little practical importance here.

## OVIPOSITION

### METHODS

Oviposition records were secured from moths caged in 7 by 10 inch battery jars. The bottoms of the jars were covered with about an inch of sand, which was moistened just enough to make it firm. The moths were fed dilute honey placed in a sponge about an inch in diameter. Oviposition was secured on apple foliage, and on sticks about the thickness of a pencil and 2 or 3 inches long. The leaves and sticks were removed daily and the eggs counted. Eggs deposited on the sides of the jars were also counted and their position marked with a red wax pencil.

All moths placed in each cage were generally taken from the same day's emergence, and varied in number from 1 to 32 females, with a similar number of males. After the first few months, 25 pairs was the maximum number placed in a cage, and later this was reduced to 20 pairs. Moths were not selected for robustness or possible fecundity, but an average lot was used. The advantages of having a large number of moths in each cage were, the increased chance of having a high percentage of females fertilized, and also that records for a large number of individuals could be secured with a minimum of handling. The disadvantages of having large numbers in a cage were that it was difficult to handle them when egg records were taken, as there was always a tendency to injure some and allow others to escape, and also that fungous diseases of moths spread more rapidly in crowded cages. It was found desirable to include in a cage moths emerging on the same day, although this practice was not strictly adhered to.

Oviposition records were taken early in the morning, when moths were relatively quiet. On warm days, after 10 a. m., there was always difficulty in removing eggs, owing to the activity of

TABLE 15.—CARPOCAPSA POMONELLA: PERIOD OF OVIPOSITION, SPRING BROOD, SHOWING NUMBER OF EGGS DEPOSITED BY MOTHS IN CAGES EACH DAY AFTER EMERGENCE AND PERCENTAGE OF TOTAL OVIPOSITION FOR EACH DAY, BENTONVILLE, ARK., 1921.

| Lot No. | Mean temperature during whole period of oviposition<br>°F. | Number of female moths | Total number of eggs deposited | Days after emergence |   |      |      |      |      |     |     |     |     |     |
|---------|------------------------------------------------------------|------------------------|--------------------------------|----------------------|---|------|------|------|------|-----|-----|-----|-----|-----|
|         |                                                            |                        |                                | 1                    | 2 | 3    | 4    | 5    | 6    | 7   | 8   | 9   | 10  | 11  |
| 1       | 74.87                                                      | 160                    | 1,821                          | Eggs deposited       | 0 | 178  | 318  | 322  | 250  | 173 | 148 | 135 | 108 | 66  |
|         |                                                            |                        |                                | Per cent of total    | 0 | 9.8  | 17.4 | 17.7 | 13.7 | 9.5 | 8.1 | 7.4 | 5.9 | 3.6 |
| 2       | 66.11                                                      | 140                    | 1,225                          | Eggs deposited       | 0 | 112  | 57   | 114  | 107  | 109 | 115 | 111 | 106 | 87  |
|         |                                                            |                        |                                | Per cent of total    | 0 | 9.1  | 4.7  | 9.3  | 8.7  | 8.9 | 9.4 | 9.1 | 8.6 | 7.1 |
| 3       | 63.71                                                      | 140                    | 454                            | Eggs deposited       | 0 | 50   | 77   | 65   | 38   | 39  | 29  | 30  | 23  | 23  |
|         |                                                            |                        |                                | Per cent of total    | 0 | 11.0 | 16.9 | 14.3 | 8.4  | 8.6 | 6.4 | 6.6 | 5.1 | 5.1 |
|         |                                                            |                        |                                |                      | 0 | 11.0 | 16.9 | 14.3 | 8.4  | 8.6 | 6.4 | 6.6 | 5.1 | 3.1 |

TABLE 15.—(Continued).

| Lot No. | Mean temperature during whole period of oviposition<br>°F. | Number of female moths | Total number of eggs deposited | Days after emergence |                   |     |     |     |      |     |    |    |     |    |    |    |    |
|---------|------------------------------------------------------------|------------------------|--------------------------------|----------------------|-------------------|-----|-----|-----|------|-----|----|----|-----|----|----|----|----|
|         |                                                            |                        |                                | Eggs deposited       | Per cent of total | 12  | 13  | 14  | 15   | 16  | 17 | 18 | 19  | 20 | 21 | 22 | 23 |
| 1       | 74.87                                                      | 160                    | 1,821                          | Eggs deposited       |                   | 37  | 22  | 9   | 1    |     |    |    |     |    |    |    |    |
|         |                                                            |                        |                                | Per cent of total    |                   | 2.0 | 1.2 | 0.5 | 0.05 |     |    |    |     |    |    |    |    |
| 2       | 66.11                                                      | 140                    | 1,225                          | Eggs deposited       |                   | 71  | 50  | 23  | 28   | 16  | 5  | 2  | 1   |    |    |    |    |
|         |                                                            |                        |                                | Per cent of total    |                   | 5.8 | 4.1 | 1.9 | 2.3  | 1.3 | .4 | .2 | .1  |    |    |    |    |
| 3       | 63.71                                                      | 140                    | 454                            | Eggs deposited       |                   | 17  | 14  | 6   | 5    | 5   | 4  | 2  | 6   | 3  | 1  | 2  | 1  |
|         |                                                            |                        |                                | Per cent of total    |                   | 3.7 | 3.1 | 1.3 | 1.1  | 1.1 | .9 | .4 | 1.3 | .7 | .2 | .4 | .2 |

the moths. Cages from which records were taken two or more times daily usually showed a decrease in the rate of oviposition due to loss or killing of moths during manipulation. Where oviposition records are taken only in the morning a fair average rate of oviposition may be secured. However, this practice gives only approximate data on preoviposition and oviposition periods.

For the purpose of comparing oviposition in light and darkness, cubical frames covered with black cloth (percale) were made, which could be placed over the cages when desired. The cloth did not exclude light entirely. For complete darkness, cages were carried to a dark cellar.

#### NORMAL OVIPOSITION

The rate of multiplication possible for the codling moth is best shown by the average number of eggs deposited by a female moth. This number varies greatly with the season of the year, or rather with the prevailing temperature. Under normal conditions oviposition generally increases with the temperature. Since temperature is most consistently high during the summer months, the number of eggs deposited per female is highest at that time. The oviposition of May and September is very low when compared with that of midsummer.

The seasonal increase and decrease in the number of eggs deposited per female moth is shown in Table 16. This table is a summary of records of total oviposition of 1,535 female moths, grouped in 96 cages, distributed at intervals of a few days throughout the seasons of 1918, 1919, and 1921. These moths were kept in the insectary under natural temperature and light conditions. Records for individual cages are not given, but each month is divided into 10-day periods, and the records for the moths which emerged in each of these periods are presented together.

It will be noted in this table that the highest average oviposition for each year was in July. The highest average for any 10-day period was 110.09 eggs to each female moth in the period from July 1 to 10, 1921. It will also be noted that no recorded average for any 10-day period in this month is below 42.32 eggs to each female. With the exception of the second 10-day period in August, in 1918, oviposition is consistently less in August than in July. In September, when cool nights are the rule, the decline in oviposition is still more marked.

The lowest oviposition of the season is that of the first part of the spring brood of moths. In 1919 the average oviposition for female moths emerging before May 21 was less than 1 egg each. In 1921 it was higher than this after May 1. As a rule, the first females to emerge do not oviposit at all and a considerable period elapses between first emergence and any appreciable oviposition. This period varies greatly from season to season.

TABLE 16.—CARPOCAPSA POMONELLA: AVERAGE NUMBER OF EGGS PER FEMALE MOTH THROUGHOUT THE SEASONS OF 1918, 1919, AND 1921, IN PERIODS OF 10 DAYS, BENTONVILLE, ARK.

| 1918                              |                        |                 |             |                                 |
|-----------------------------------|------------------------|-----------------|-------------|---------------------------------|
| Dates of emergence of moths       | Number of female moths | Number of cages | Oviposition | Aver. number of eggs per female |
| June 11-20                        | 6                      | 2               | 103         | 17.17                           |
| 21-30                             | 154                    | 9               | 4,923       | 31.96                           |
| July 1-9                          | 34                     | 3               | 1,823       | 53.62                           |
| 10-19                             | 70                     | 3               | 5,149       | 73.56                           |
| 20-31                             | 54                     | 2               | 2,623       | 48.57                           |
| Aug. 1-10                         | 37                     | 2               | 1,488       | 40.22                           |
| 11-20                             | 31                     | 2               | 1,996       | 64.39                           |
| 21-31                             | 24                     | 2               | 734         | 30.58                           |
| Sept. 1-10                        | 9                      | 2               | 52          | 5.78                            |
| 11-20                             | 3                      | 1               | 31          | 10.33                           |
| 1919                              |                        |                 |             |                                 |
| April 20-30                       | 8                      | 2               | 4           | .50                             |
| May 1-10                          | 49                     | 3               | 39          | .79                             |
| 11-20                             | 61                     | 3               | 54          | .88                             |
| 21-31                             | 67                     | 3               | 354         | 5.28                            |
| June 1-10                         | 82                     | 4               | 728         | 8.88                            |
| 11-20                             | 19                     | 2               | 81          | 4.26                            |
| 21-30                             | 7                      | 2               | 329         | 47.00                           |
| July 1-10                         | 39                     | 3               | 2,075       | 53.20                           |
| 11-20                             | 20                     | 1               | 1,354       | 67.70                           |
| 21-31                             | 20                     | 1               | 1,086       | 51.30                           |
| Aug. 1-10                         | 24                     | 2               | 932         | 38.83                           |
| 11-20                             | 47                     | 2               | 1,568       | 33.36                           |
| 21-31                             | 59                     | 2               | 2,307       | 39.10                           |
| Sept. 1-7                         | 60                     | 2               | 1,521       | 25.35                           |
| 8-20                              | 13                     | 1               | 167         | 12.85                           |
| 1921                              |                        |                 |             |                                 |
| April 21-30                       | 13                     | 2               | 4           | .31                             |
| May 1-10                          | 58                     | 5               | 474         | 8.17                            |
| 11-20                             | 111                    | 9               | 1,624       | 14.63                           |
| 21-31                             | 140                    | 7               | 1,463       | 10.21                           |
| June*                             |                        |                 |             |                                 |
| July 1-10                         | 107                    | 6               | 11,780      | 110.09                          |
| 11-20                             | 69                     | 4               | 4,716       | 68.35                           |
| 21-30                             | 40                     | 2               | 1,693       | 42.32                           |
| Totals -----                      | 1,535                  | 96              | 53,275      | 34.71                           |
| Totals for overwintering broods-- | 608                    |                 | 4,825       | 7.94                            |
| Totals for summer broods -----    | 927                    |                 | 48,450      | 52.27                           |

\*No records taken.



The deposition of a total of 53,275 eggs was recorded for the 1,535 female moths, or an average of 34.71 eggs each. This average is probably less than it should be because a large proportion of moths, 608, or nearly two-fifths, were of the spring brood, whose total recorded oviposition was only 4,825, or an average of 7.94 each. For the 927 moths of the summer broods, a total oviposition of 48,450 was recorded, or an average of 52.27 to each female.

The records given in Table 16 do not show the extreme fecundity, but are averages for 10-day periods. During each period there were some cages in which the number of eggs deposited was much higher than the average for the period. The highest record for any cage was an average of more than 147 eggs for each female for a total of 15 pairs of moths which emerged July 2, 1921. Records for the three highest cages are shown in Table 17.

TABLE 17.—CARPOCAPSA POMONELLA: OVIPOSITION RECORDS FOR THREE CAGES SHOWING HIGHEST AVERAGE FECUNDITY, BENTONVILLE, ARK., 1921.

| Cage number | Date of emergence of moths | Number of pairs of moths | Total oviposition | Average oviposition per female |
|-------------|----------------------------|--------------------------|-------------------|--------------------------------|
| f01         | July 1                     | 12                       | 1585              | 132.91                         |
| 103         | 2                          | 15                       | 2213              | 147.53                         |
| 109         | 8                          | 20                       | 2487              | 124.35                         |

Average fecundity, rather than extreme individual fecundity, was regarded as of most importance; hence relatively little attention was given to individual oviposition records of moths.

TABLE 18.—CARPOCAPSA POMONELLA: HIGHEST OVIPOSITION RECORDS FOR ISOLATED PAIRS OF MOTHS.

| Date of emergence of moths | Oviposition |
|----------------------------|-------------|
| July 5                     | 214         |
| 5                          | 203         |
| 5                          | 144         |
| 5                          | 131         |
| 3                          | 125         |

On July 3 and 5, 1921, however, 16 pairs were isolated in oviposition cages. In three of these cages no eggs were secured and in a number the oviposition was scant. The highest record for any of these 16 females was 214 eggs. The five highest individual records are given in Table 18. It is possible that higher records could have been secured had a larger series of moths been used.

#### LIMITING FACTORS

The prevailing temperature has been mentioned as a factor which greatly modifies the number of eggs deposited by a female moth. There are other factors which also modify or limit the number of eggs deposited, the most important of which appears to be the degree of light prevailing at the time of oviposition.

It is probable that relative humidity, as well, may be an important factor affecting oviposition, though no records of humidity were kept.

Precipitation is probably a factor of some importance in orchards, as heavy rains may destroy adult moths mechanically.

#### EFFECT OF LIGHT AND DARKNESS ON OVIPOSITION

Oviposition, according to records at Bentonville, usually occurred in the evening (with failing light), or at night. This was shown by two short series of experiments in 1919, the results of which are summarized in Table 19. Oviposition records for the moths in cages involved in the experiments were taken twice daily, once at 8 a. m. and once just before sunset. The jars were exposed to normal light in the insectary but not to direct sunlight. In 1919 a total of 55 female moths with a similar number of males in three cages were used during the greater part of their oviposition period. Eggs deposited by day, before sunset, amounted to 6.91 per cent, while those deposited after sunset amounted to 93.09 per cent. The percentage of night oviposition was so strikingly high that further experiments to test this point were considered unnecessary.

It was shown, however, by other experiments, that the factor controlling the time of oviposition was not the time of the day, but the relative degree of light or darkness. In 1919, four cages containing a total of 84 moths were kept covered continuously by black cloth (percale) during the greater part of the oviposition, and records were taken twice daily as before. In these darkened cages the oviposition by day was 48.47 per cent and the night oviposition 51.53 per cent. (See Table 19.)

A record of oviposition in absolute darkness was taken from three other cages, with a total of 61 moths, which were placed in a dark cellar. The experiment extended over a similar period and oviposition records were taken in the same way. In these cages, 66.85 per cent of the oviposition occurred by day. (See Table 19.) It is probable that the higher temperature by day

was the factor inducing the greater oviposition at that time, as the darkness was practically constant throughout the 24 hours.

TABLE 19.—CARPOCAPSA POMONELLA: OVIPOSITION BY DAY AND AT NIGHT, BENTONVILLE, ARK., 1919.

| In Cages Exposed to Normal Light in Insectary  |                        |                          |          |
|------------------------------------------------|------------------------|--------------------------|----------|
| Date of emergence of moths                     | Number of female moths | Number of eggs deposited |          |
|                                                |                        | By day                   | At night |
| July 18                                        | 15                     | 50                       | 455      |
| 30                                             | 20                     | 71                       | 1,059    |
| Aug. 2                                         | 20                     | 12                       | 278      |
| Total -----                                    | 55                     | 133                      | 1,792    |
| Per cent --                                    |                        | 6.91                     | 93.09    |
| In Cages in Insectary, Darkened by Black Cloth |                        |                          |          |
| July 19                                        | 10                     | 120                      | 190      |
| 31                                             | 24                     | 443                      | 301      |
| Aug. 1                                         | 25                     | 150                      | 345      |
| 4                                              | 25                     | 176                      | 109      |
| Total -----                                    | 84                     | 889                      | 945      |
| Per cent --                                    |                        | 48.47                    | 51.53    |
| In Cages in Dark Cellar                        |                        |                          |          |
| July 17                                        | 16                     | 290                      | 90       |
| 28                                             | 25                     | 231                      | 180      |
| Aug. 3                                         | 20                     | 78                       | 27       |
| Total -----                                    | 61                     | 599                      | 297      |
| Per cent --                                    |                        | 66.85                    | 33.15    |

The relation of light and darkness to oviposition was tested in another way in 1920. Six cages (see Table 20) were used in an experiment in which, during the day, the moths were alternately exposed to light and to darkness at intervals of two or three hours, and oviposition was recorded at every change. The hours of light and darkness to which the moths were exposed during the day were approximately equal. Considering the entire experiment, 71.88 per cent of the oviposition occurred by day, and all of this was during the time when the cages were darkened. No eggs were deposited in normal light. Oviposition

by day was secured or stopped at will, by darkening the cages or exposing them to light.

TABLE 20.—*CARPOCAPSA POMONELLA*: OVIPOSITION BY DAY IN NORMAL LIGHT, BY DAY IN DARKENED CAGES, AND AT NIGHT, BENTONVILLE, ARK., 1920.

| Moths alternately exposed to light and to darkness |                            |                        |              |                |       |       |
|----------------------------------------------------|----------------------------|------------------------|--------------|----------------|-------|-------|
| Cage No.                                           | Date of emergence of moths | Number of female moths | Oviposition  |                |       |       |
|                                                    |                            |                        | Normal light | Darkened cages | Night | Total |
| 1                                                  | July 22                    | 17                     | 0            | 150            | 27    | 177   |
| 2                                                  | 24                         | 6                      | 0            | 128            | 15    | 143   |
| 3                                                  | 25                         | 5                      | 0            | 34             | 87    | 121   |
| 4                                                  | 28                         | 4                      | 0            | 30             | 3     | 33    |
| 5                                                  | 29                         | 5                      | 0            | 108            | 21    | 129   |
| 6                                                  | 29                         | 5                      | 0            | 28             | 34    | 62    |
| Total --                                           |                            | 12                     | 0            | 478            | 187   | 665   |
| Per cent                                           |                            |                        |              | 71.88          | 28.12 |       |

All experiments on the relation of light to oviposition discussed thus far were carried out with moths in midsummer, when oviposition is high. In 1921, six cages with a total of 67 female moths of the spring brood were used. (See Table 21.) These

TABLE 21.—*CARPOCAPSA POMONELLA*: OVIPOSITION BY MOTHS OF THE SPRING BROOD, BY DAY IN NORMAL LIGHT, BY DAY IN DARKENED CAGES, AND AT NIGHT, BENTONVILLE, ARK., 1921.

| Cage No.   | Date of emergence of moths | Number of female moths | Oviposition      |                                  |       |       |
|------------|----------------------------|------------------------|------------------|----------------------------------|-------|-------|
|            |                            |                        | Day-normal light | Day-1 to 4 p. m., cages darkened | Night | Total |
| 3*         | April 23-25                | 11                     | 0                | 165                              | 58    | 223   |
| 9          | May 9                      | 13                     | 0                | 51                               | 56    | 107   |
| 11         | 10                         | 11                     | 0                | 50                               | 54    | 104   |
| 28         | 15-16                      | 10                     | 4                | 59                               | 119   | 182   |
| 30         | 15-16                      | 10                     | 0                | 91                               | 124   | 215   |
| 33         | 17                         | 12                     | 0                | 90                               | 142   | 232   |
| Total ---- |                            | 67                     | 4                | 506                              | 553   | 1,063 |
| Per cent-- |                            |                        | .38              | 47.60                            | 52.02 |       |

\*Cage 3 was kept in office where temperature was higher than in insectary.

cages were exposed to normal light during the day, except from 1 to 4 p. m., when they were darkened with black cloth covers. The percentages for the three-hour darkened period of the day, for the normal light by day, and for night were 47.60, 0.38, and 52.02 per cent, respectively.

Comparative records were also taken for moths in midsummer, at the height of oviposition. Two cages (See Table 22), containing a total of 40 pairs of moths, were exposed to normal light by day. Four cages, containing a total of 69 pairs of moths, were exposed to normal light except from 1 to 5 p. m., when they were covered. In the uncovered cages, 96.11 per cent, practically all of the oviposition, occurred at night. On the other hand, in cages artificially darkened in the afternoon, only 62.51 per cent of the eggs were deposited at night, while the remainder were deposited during the period of artificial darkness.

TABLE 22.—CARPOCAPSA POMONELLA: OVIPOSITION BY DAY AND AT NIGHT, BENTONVILLE, ARK., 1921.

| Cages exposed to normal light    |                            |                       |                                       |                   |                   |
|----------------------------------|----------------------------|-----------------------|---------------------------------------|-------------------|-------------------|
| Cage No.                         | Date of emergence of moths | No. of pairs of moths | Afternoon oviposition by normal light | Night oviposition | Total oviposition |
| 105                              | July 4                     | 20                    | 72                                    | 1,773             | 1,845             |
| 108                              | 7                          | 20                    | 78                                    | 1,936             | 2,014             |
|                                  | Total ---                  | 40                    | 150                                   | 3,709             | 3,859             |
|                                  | Per cent                   |                       | 3.89                                  | 96.11             |                   |
| Cages darkened from 1 to 5 p. m. |                            |                       |                                       |                   |                   |
| 107                              | July 6                     | 20                    | 348                                   | 1,291             | 1,639             |
| 109                              | 8                          | 20                    | 1,005                                 | 1,482             | 2,487             |
| 111                              | 12                         | 15                    | 669                                   | 480               | 1,149             |
| 112                              | 13                         | 14                    | 448                                   | 866               | 1,314             |
|                                  | Total ---                  | 69                    | 2,470                                 | 4,119             | 6,589             |
|                                  | Per cent                   |                       | 37.49                                 | 62.51             |                   |

A peculiarity of the oviposition in normal daylight which occurred in the experiments summarized in Tables 19 and 22, was that this oviposition did not represent scattering eggs of many moths, but a rather heavy egg deposition of a very few. In several cages not included in these records, an occasional moth was observed late in the afternoon actively ovipositing, apparently regardless of the light. It is possible that these moths were in-

dividuals of extremely high fecundity which could not wait for night to begin oviposition.

Daytime oviposition by moths of the spring brood almost never occurred.

From the foregoing experiments it was concluded that at least an appreciable degree of darkness is an essential condition for heavy oviposition.

## EFFECT OF TEMPERATURE\*

### CONDITIONS OF EXPERIMENT

The following data on the relation of temperature to oviposition are based on egg records of 1,280 moths of the spring brood of 1921. The emergence of the moths used in this experiment occurred between May 20, when emergence of the brood was at its crest, and May 31. Oviposition extended between May 22 and June 17.

All oviposition records were secured in glass battery jar cages, already described, each of which contained 20 pairs of moths. All moths in each cage were taken from a single day's emergence. The 32 cages used were divided into 6 lots, as follows:

Lot 1, consisting of 8 cages (Nos. 41-48), was placed in the insectary at normal light and temperature. During the oviposition period the temperature ranged from 60° to 87° F., with an average of 74.87°. Temperature at sunset, or just before the time when oviposition began, varied from 71° to 82° F.

Lot 2, consisting of 7 cages (Nos. 51-57), was placed on a shelf in a cellar under the laboratory. The cellar was continuously dark. Temperature in the cellar was fairly constant, never varying more than 3 degrees in a day and usually not more than 2 degrees. The extremes of temperature during the period in which oviposition occurred were 64° and 69° F. On all but 3 of the 22 days the thermometer never fell below 65°, and on only 3 days it rose to about 67.5°. The mean temperature for the period was 66.11° F.

Lot 3, consisting of 7 cages (Nos. 61-67), was in the same cellar as Lot 2, but about 4 feet lower and on the floor. The con-

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\*In a recent study of the codling moth, P. A. Glenn gives special attention to temperature and the rate of development. He states: "For practical purposes, 50° may be used as the zero of development and 86° as the degree of maximum rate of development, and the effective day-degree for any day may be determined by finding the average temperature above 50° and subtracting from it twice the average temperature above 86°."

"The first larvae of the first, second and third generations enter the fruit when the accumulations of effective day degrees have reached about 550; 1,550 and 2,550 day degrees respectively."

For a complete account see Glenn, P. A., Codling moth investigations of the State Entomologist's Office, 1915, 1916, 1917. Ill. Nat. Hist. Survey Bul. 14, pp. IV, 219-289, 1922.

ditions were about the same, except that the temperature was lower and the daily variation even slightly less. The extremes of temperature were  $61^{\circ}$  and  $65^{\circ}$ , but except for 5 days it was never less than  $63^{\circ}$ . The mean was  $63.71^{\circ}$  F.

Lot 4, consisting of 6 cages (Nos. 61 to 66), was also in a cellar, which was slightly warmer and more variable. The extremes in this cellar were  $64^{\circ}$  and  $71^{\circ}$ , and the mean  $67.86^{\circ}$  F.

Lot 5 consisted of 2 jars and was kept in a refrigerator, on the upper shelf, with temperatures ranging from  $58.5^{\circ}$  to  $62^{\circ}$ , the mean being  $60.95^{\circ}$ .

Lot 6 consisted of 2 jars, kept on the lower shelf of a refrigerator, with temperatures ranging from  $54^{\circ}$  to  $60^{\circ}$  and with a mean of  $55.95^{\circ}$ .

The cages in Lots 1 to 4 were kept under the conditions stated throughout the life of the moths. The cages in Lots 5 and 6 were kept in the refrigerator at the temperature stated only  $5\frac{1}{2}$  and 6 days, respectively.

All temperature records were taken with maximum and minimum thermometers. Those in the insectary were read twice daily, about sunset and at 8 a. m. Other records were taken once a day. The mean temperature given is the average of the maximum and minimum readings. Recently it has been pointed out that an average of thermometer records may not represent a true mean, but in the case of all lots, except No. 1, the variation is so slight that at least a practical mean is represented by the average temperature.

#### DISCUSSION

It had been assumed that the average oviposition for each female moth declined with a decline of temperature below optimum conditions. It was the purpose of this experiment to determine, if possible, the temperature at which oviposition was perceptibly checked, or was stopped altogether.

The assumption that the amount of oviposition declined with a decline of temperature was borne out, as is shown from the records of cage Lots 1, 2, 3, and 4. The order in height of temperature is exactly the same as the order of average number of eggs. (See Table 23.)

In Lot 3, in which the temperature never exceeded  $65^{\circ}$  and averaged  $63.71^{\circ}$ , a marked checking of oviposition is shown. But in spite of small numbers of eggs deposited, oviposition in this lot was as regular as in any of those with higher temperatures. In this lot on 13 days the temperature did not exceed  $64^{\circ}$ , yet on all these days some eggs were deposited.

In Lots 5 and 6, with the temperature continuously below  $62^{\circ}$ , no oviposition was secured. The moths in two cages used in these lots had first been exposed to a higher temperature and had then shown a relatively high fecundity. After the close of the

test they were again placed at a higher temperature and again began ovipositing.

No tests were made with the maximum temperature between 62° and 64°. In two instances, however, records were secured in cages which during a 12-hour period had been exposed to a temperature not higher, at any time, than 63°. In both instances scant oviposition occurred.

On the basis of these records it may be concluded that, while oviposition decreases with a declining temperature, nevertheless it receives no serious check until a temperature of about 65° is reached. Below 65° F. oviposition is scant. Below 62° oviposition stops altogether.

TABLE 23.—CARPOCAPSA POMONELLA: SUMMARY OF OVIPOSITION RECORDS AT DIFFERENT TEMPERATURES, BENTONVILLE, ARK., MAY 20 TO JUNE 17, 1921.

| Lot No. | Temperature |         |       | Number of cages in lot | Number of female moths | Time exposed to given temperature | Total number of eggs deposited by the lot | Average number of eggs deposited per cage of 20 pairs |
|---------|-------------|---------|-------|------------------------|------------------------|-----------------------------------|-------------------------------------------|-------------------------------------------------------|
|         | Maximum     | Minimum | Mean  |                        |                        |                                   |                                           |                                                       |
|         | °F.         | °F.     | °F.   |                        |                        |                                   |                                           |                                                       |
| 1       | 87          | 60      | 74.87 | 8                      | 160                    | Life of moths                     | 1,821                                     | 227.62                                                |
| 4       | 71          | 64      | 67.86 | 6                      | 120                    | Life of moths                     | 1,216                                     | 202.66                                                |
| 2       | 69          | 64      | 66.11 | 7                      | 140                    | Life of moths                     | 1,225                                     | 175.00                                                |
| 3       | 65          | 61      | 63.71 | 7                      | 140                    | Life of moths                     | 454                                       | 64.85                                                 |
| 5       | 62          | 58.5    | 60.95 | 2                      | 40                     | 5½ days                           | 0                                         | 0                                                     |
| 6       | 60          | 54      | 55.95 | 2                      | 40                     | 6 days                            | 0                                         | 0                                                     |

#### SIGNIFICANCE OF FACTORS LIMITING OVIPOSITION

The importance of conditions unfavorable to oviposition has not been fully appreciated. Conditions unfavorable to the development of the codling moth at any other period of its life history, as a rule, merely check the development of the stage in question for a time. But if, for a certain period, oviposition is checked or stopped altogether, the moths present may fail to give rise to a succeeding generation.

The significance of limiting factors receives fuller attention in the discussions of seasonal and local variation in abundance of moths, and of the forecasting of broods.

#### SUNSET TEMPERATURE AND SPRING-BROOD OVIPOSITION

The data obtained in the oviposition study were confirmed by comparison of the oviposition records of the spring brood of moths with the sunset temperatures on the days preceding those on which oviposition occurred. At the time most of the oviposition records were taken, no thought was given to the minimum



temperature at which oviposition might occur. In fact, the records of temperature at sunset were obtained from the station of the U. S. Weather Bureau at Bentonville after all oviposition records had been completed. Sunset records in the insectary were taken only in 1921.

In 1918 temperature at sunset first passed 62° F. on May 2, and continued favorable for oviposition. A scant emergence of moths began April 29, but it did not begin in any numbers until May 4. First oviposition was recorded May 6, only two days later.

In 1919 oviposition began three times, or rather was stopped twice after beginning, owing to unfavorable temperatures. Light emergence of moths had been in progress for 12 days before the sunset temperature rose above 62°. It passed this temperature on May 2, and oviposition was recorded the following morning, and the succeeding days until May 7. From May 7 to May 12, inclusive, the temperature dropped below 62° before sunset and no eggs were deposited. From May 13 to 18, the sunset temperature was again favorable, and oviposition was recorded regularly on the mornings of May 12 to 19. Again, the sunset temperature dropped until May 22, and from then on continued favorable. Oviposition stopped with the decline of temperature and was not recorded again until May 25, when the period of heavy oviposition began.

The beginning of oviposition in 1920 was similar to that of 1918. Favorable sunset temperatures occurred a few days before moths were present in numbers. While the first moths to emerge were recorded April 30, the first emergence of any numbers was on May 5. The first oviposition was secured May 7, two days later.

In 1921 the first emergence was recorded April 13. The first record of sunset temperature above 62° F. in the insectary was on May 8. Oviposition was secured that night.

## SEASONAL AND LOCAL VARIATION IN ABUNDANCE

The degree of codling moth infestation in the Ozarks varied greatly from year to year, even in the same orchard, but more striking still was the variation in different orchards, and sometimes in different parts of the same orchard, during the same year. The determination of the cause of this variation was regarded as one of the most important phases of the codling moth problem.

### SEASONAL VARIATION IN CODLING MOTH INFESTATION

The seasonal variation in the degree of injury by the codling moth is due largely to the difference in weather conditions from one year to another.

It is apparent, from a study of the abundance of the codling moth at different times throughout the year, that the critical period in its seasonal history is between hibernation and the hatching of the first brood. When the larvae are leaving the fruit in the fall, they are often more than 100 times as abundant in the orchard as were the first-brood larvae in the fruit the preceding spring. Yet each succeeding spring they are set back in numbers, although not always to the same extent. The seriousness of the codling moth problem during the seasons under the writers' observation has been in direct proportion to the size of the first brood.

The cold winter doubtless kills some of the hibernating larvae. In the insectary as high as 40 per cent of the hibernating larvae died during winter. In part, however, this must be attributed to injury inflicted on larvae in removing them from cocoons under bands and transferring them to pupation sticks. The cold of winter, as a setback to the codling moth in this region, loses much of its importance by a comparison of codling moth mortality during the extremely cold winter of 1917-18, when the thermometer dropped to 15° below zero, with that during the mild winter of 1920-21, when the lowest record was 8° above zero. The larval mortality was only 15 per cent higher the first year than the second. Furthermore, the most severe infestation of the codling moth of which the writers have record occurred in 1918, following the most severe winter.

Destruction of hibernating larvae by natural enemies may be of some importance, at least locally.

The period of oviposition of moths that have overwintered as larvae, rather than the conditions that exist during the hibernation period, appears to the writers to be the critical period in the seasonal history of the codling moth. The success of the codling moth during a given season depends quite largely upon weather conditions at this time. In the season of 1919, a year of a very light codling moth infestation, emergence of moths began April 20, but heavy oviposition did not begin until May 25, an interval of 35 days. This was due, apparently, to the fact that the night temperature during that interval was unfavorable to oviposition. By that time more than half the spring-brood moths had emerged and the majority had died without ovipositing. As a result, the first brood of larvae was very small.

In the preceding year, 1918, which was remarkable for the serious loss of fruit due to the codling moth, the beginning of heavy emergence of moths and favorable weather for oviposition were almost simultaneous. As a result, there was a relatively large first brood of larvae.

The night temperature throughout the oviposition periods of the later broods is also of importance in affecting the rate of multiplication of the codling moth. It is not of critical im-

portance, however, for at no time during the summer is temperature so low that reproduction is stopped altogether.

In general, it may be stated that a long period of warm nights during the month of May is the condition most likely to indicate a season of severe codling moth infestation.

#### LOCAL VARIATIONS IN CODLING MOTH INFESTATION

The differences in infestation in different orchards, even during the same season, are far more striking than the variations from season to season in the same orchard. As an example of this, two orchards near Bentonville may be compared, one called A and the other B. These orchards were less than 2 miles apart. The following observations were made in 1920:

**Orchard A.** Practically all of the orchard had been sprayed for the codling moth six times, including the calyx application. The spraying had not been done in the most thorough manner possible, as some of the low-hanging fruit had been missed altogether, yet the work had been better than the average. The codling moth appeared to be fairly well under control until the latter part of August. When the Ben Davis crop was harvested, between 60 and 70 per cent of the fruit was "wormy", and, taking the extra "worms" per apple into consideration, the infestation was estimated at about 300 per cent. On a few unsprayed trees, more than 90 per cent of the fruit dropped before harvest, owing to codling moth injury.

**Orchard B.**—This orchard had received the same number of spray applications as Orchard A and the work had been done about the same time, but had been distinctly less thorough than in Orchard A. Nevertheless, in this orchard the codling moth infestation was very light at harvest—less than 5 per cent. The infestation in this orchard had been relatively light, when compared with nearly all orchards, for at least the three preceding seasons, although control measures had never been quite up to the standard.

Illustrations of similar contrasts might be multiplied, but these two orchards indicate the degree of variation in local infestation. Variation in abundance of the codling moth is observed not only in different orchards, but often in parts of the same orchard.

Local differences in natural infestation may be ascribed to various causes, of which the following are most important: Local occurrences of natural enemies of the codling moth, parasitic or predatory; variation in regular bearing of orchards due to frost, care, etc.; difference among apple varieties in susceptibility to codling moth attack; local differences in temperature during the period of oviposition, particularly by moths of the spring

brood. It is the opinion of the writers that the last two factors named are usually the most important.

#### IRREGULAR CROPS

It is well understood that a light infestation of codling moth may be expected in orchards in which there has been only a scanty crop the preceding year, due to frost or any other cause. In orchards which are subject to serious injury from fungous diseases, particularly scab and blotch, which result in an early dropping of fruit, the codling moth problem is often not as serious as in orchards which have fairly good crops. In the Ozarks the writers have usually found the codling moth problem to be most severe in orchards which bear regular crops.

#### NATURAL ENEMIES

The records taken by the writers do not show the codling moth in the Ozarks to be heavily parasitized. While no special attention was given to parasitism, yet more than 70 per cent of the codling moths reared were collected in the field, either as partly grown larvae in fruit or as mature larvae and pupae under bands, so that an approximate record of parasitism should have been obtained. Yet the total number of parasites reared was much less than 1 per cent of the total number of moths. From observations of parasite cocoons in codling moth cocoons under bands, the percentage appeared to be much higher than this in some orchards, but on the whole the average shown in rearing records is probably near the true proportion.

The codling moth appears to be attacked most frequently as the full-grown larva in the cocoon. The parasites most often reared were three ichneumonids—*Ephialtes aequalis* Prov.,\* *Itoplectis conquisitor* Say\*, and *Epiurus indigator* Prov.\* *Macrocetrus* sp.† was also reared from codling moth cocoons, but apparently attacks its host as a partly grown or possibly quite small larva in the apple. *Cremastus epagages* Cush.\* was also reared from codling moth material secured in the field, and is apparently strictly a larval parasite.

No specimens of *Ascogaster carpocapsae* Viereck, the most common parasite of the codling moth in the North and East, were reared.

The predatory enemies of the codling moth were by far more important than the parasitic enemies. Like the latter, they attacked the host in the cocoon. A great many beetles of the family Carabidae were found under bands, and the following were found feeding on codling moth larvae: *Cymindis pilosa* Say†, *Anisodactylus rusticus* Dejean†, *Tenebroides corticalis* Melsh†, and *Harpalus pennsylvanicus* DeG.† Carabid larvae and the larva of a

\*Determined by R. A. Cushman.

†Determined by E. A. Schwarz.

‡Determined by S. A. Rohwer.

malachid—*Collops 4-maculatus* Fab.† were frequently found in codling moth cocoons. The most important insect predator was a clerid larva which was fairly common in cocoons of the overwintering larvae.

Probably by far the most important natural enemies of the codling moth in this region are woodpeckers, particularly the red-bellied woodpecker. This species is abundant locally, and in some orchards which adjoin woodlots the majority of cocoons of the codling moth are apparently opened by this bird.

#### DIFFERENCE IN VARIETAL SUSCEPTIBILITY TO CODLING MOTH INJURY

The varieties of apples that occur in an orchard and their arrangement in planting often lighten or intensify the severity of the codling moth problem in that orchard.

Perhaps the most obvious factor by which a variety affects the success of the codling moth is its time of harvest. If the codling moth is to be successful in an orchard, it is necessary that at least a fair percentage of the trees be of a variety which is not harvested until late enough in the season to permit the development of three or nearly three full broods. If a block of trees includes only varieties which are early enough to make this impossible, the late-developing larvae, which make up most of the overwintering individuals, do not have opportunity for development. Even in varieties which are harvested as late as the last of August and the first of September, such as Jonathan and Grimes, the majority of the last brood of codling moth larvae do not have time to mature. As a result, when these varieties are planted in blocks isolated from late varieties, they are relatively little troubled with the codling moth.

Transparent and Early Harvest, which in this region are harvested between June 15 and July 1, are out of the orchard before hatching of the second brood of the codling moth is well under way and thus escape a heavy infestation. By June 15 only a part of the first brood has had time to mature. If planted in blocks by themselves, these varieties should present no codling moth problem.

Where there is a mixed planting of early and late varieties, however, the problem is likely to be complicated. The late varieties make it possible for the codling moth to be carried through the season successfully and thus insure an overwintering brood. There is almost no more difficult problem in codling moth control than that presented by a midseason variety like Maiden Blush in a mixed planting with late varieties. Maiden Blush is particularly susceptible to injury when ripening, and ripens at a time when second-brood larvae are hatching in enormous numbers. As a result, it is necessary that the fruit be protected with

†Determined by E. A. Schwartz.

spray until the time it is harvested, and even this is not altogether effective. Jonathan and Grimes are also often severely injured when planted in mixed blocks with late varieties.

Among the varieties which are harvested late enough in the season to permit full development of all broods of the codling moth, there is a marked variation in degree of susceptibility to injury. As for instance, in an orchard which included Winesap, Kinnard, Ben Davis, and Delicious, in September, 1920, the writers found apples of the two first-named varieties with an estimated infestation of about 15 per cent; the infestation of the Ben Davis apples was about 40 per cent, and of the Delicious about 65 per cent. In all the writers' field observations, where conditions were directly comparable, the order of severity of infestation for these varieties was the same, although such extreme differences did not always occur.

Field observations recorded below on the degree of resistance to the codling moth were made only on those varieties that occurred in orchards in which the varieties were so arranged that a comparison between them might be fairly made. This list, however, includes all of the more common late varieties grown in the Ozarks, harvested later than Grimes and Jonathan, except Collins. No laboratory tests were made. The list is as follows:

Relatively resistant: Winesap, Red Limbertwig, Kinnard, and Beach.

Medium: Ben Davis, Gano, Ingram.

Susceptible: York, Arkansas Black, Arkansas (Mammoth Black Twig), Rome.

Very susceptible: Delicious, Stayman.

The cause of varietal differences in susceptibility to the codling moth can be understood in part by observing the activities of a newly hatched codling moth larva when placed on the surface of an apple. It wanders about, guided entirely by chance, making frequent trials at piercing the apple skin. If it chances to come in contact with some roughness of the surface, such as a healed curculio puncture or a healed bruise, entry is made almost at once. Any roughness on the surface of an apple, which gives the little larva something to brace against, is a great mechanical advantage which it seldom fails to use. On the other hand, if the surface of the apple is quite smooth, a large percentage of larvae fail altogether to enter the apple, unless they happen to run into the calyx cavity.

These laboratory observations on the activities of newly hatched larvae are borne out by common knowledge of the relation of mechanical advantages to the degree of codling moth injury. It has long been known that when apples touch, or when an apple comes in contact with a twig or leaf, the chance of infestation of such apples at the point of contact is much greater than of apples which have nothing in contact with the surface. It is

probable that as many larvae attempt to enter the apples which offer no mechanical advantage for entry as those which do not, but in the former case the majority are unsuccessful. The high percentage of larvae which enter the calyx end of the apple is doubtless due to the mechanical advantage offered. For the same reason, codling moth control in orchards in which the fruit has been badly bruised by hail often presents a very difficult problem.

There is apparently a great deal of variation in the ease or difficulty with which newly hatched larvae penetrate the skin of different varieties of apples. It is probable that the toughness of the skin and the roughness of its surface are characters of importance. But among late apples the only character which can be correlated, with any consistency, with the degree of resistance to the codling moth is extreme lateness in the time of ripening, that is, the greater the interval between the cessation of hatching of larvae and the ripening of fruit, the greater the apparent resistance to injury.

The varieties which are most susceptible, Stayman and Delicious, ripen a little earlier than any of the others except Kinnard. Jonathan, Grimes, and a number of the early varieties are fully as susceptible to infestation as Stayman and Delicious, if planted with late varieties. On the other hand, Winesap and Red Limbertwig, which are perhaps least attacked by the codling moth, are also among the very latest to ripen and are usually harvested a few weeks after the hatching of codling moth larvae has practically ceased.

However, there are exceptions which show that the time of ripening is not the only consideration. The most striking exception to this correlation is Kinnard, which, as far as the writers have observed, is not heavily infested, but is about the first of the varieties listed to ripen. Ingram also does not follow the rule, as it is one of the latest varieties to ripen but is almost, if not quite, as severely injured as Ben Davis.

It should be stated here that when the codling moth larvae can penetrate the apple skin very easily, following hail injury, or when fruit of a variety like Maiden Blush is ripening, even spraying is relatively much less effective than normally. When a codling moth larva wanders over the surface of a sprayed apple, hunting for a place to enter, it is apt to be poisoned before finding it, even if the surface is not perfectly covered. If, however, entry is easy, the chance of being poisoned is greatly reduced. It frequently happens that a larva is able to enter an apple through a spot of poison. This is due to the fact that most of the skin and pulp bitten off by the larva in starting the hole into the apple is not eaten but is thrown into the web with which it closes up its hole after it has entered the apple. Thus, anything which shortens its period of wandering over the surface of the fruit in-

creases its chance of escaping poison. With some varieties this period is distinctly shorter than with others.

#### LOCAL VARIATIONS IN TEMPERATURE

The fact that variations in temperature may occur among orchards in the same vicinity is very generally known. Usually, a fruit grower thinks of this only in relation to the frost hazard in the spring. In the Ozarks, at least, it is usual that frosts are local rather than general and that damage is more frequent in certain orchards than in others. But hitherto the effect of local temperatures on insect development has received little consideration.

To determine the extent of the temperature variation that may occur between orchards in the same vicinity, thermograph records were taken in two orchards in the late summer of 1920 and continued in the spring of 1921. Each thermograph was checked throughout the entire period of use by a maximum and minimum thermometer. These two orchards were selected because they contrasted markedly in their tendency to become infested with the codling moth. The records were not entirely satisfactory, as a change of orchards was necessitated early in 1921. However, the records serve, at least, to show that variations in temperature, particularly at night, do occur, which would very materially affect the reproductivity of the codling moth.

A typical example is given by thermograph records from May 24 to 30. One record is from an orchard with a high natural infestation (Orchard A). The other record is from an orchard with a low natural infestation (Orchard B) (Fig. 3).

By comparing the thermograph records it will be noted that the maximum temperatures in the two orchards were very similar, often being the same, the greatest difference being 3° F. Neither orchard consistently held the high records for each day. On the other hand, the minimum temperatures differed noticeably, the greatest difference for a single night being 8° F.

Perhaps the greatest difference in the temperature variations of the two orchards was in the rapidity of the fall of temperature in the evening, particularly between 6 and 8 o'clock.

As a rule, the temperature declined much more rapidly in Orchard B, this decline being greatest just before dark and immediately after it. In Orchard A, the decline was much less rapid at this time than in Orchard B.

The effect on temperature of a thunder shower about 6 o'clock is shown in the record for the last day. Local showers often occur in one orchard and not in another.

It has previously been stated that probably the most critical period in the seasonal history of the codling moth is the period



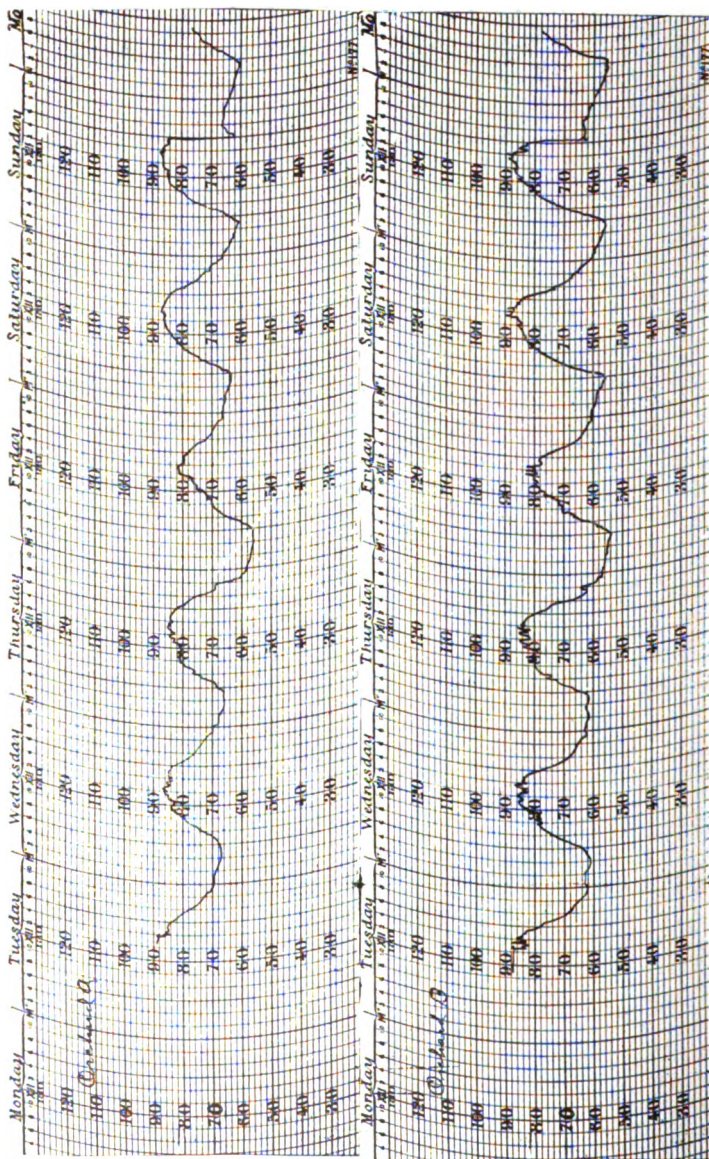


FIG. 3.—Thermograph records in two orchards for May 24 to 30, 1921, showing extent of variation in temperature, Bentonville, Ark.

of oviposition by moths from the overwintering larvae, and that the factor of most importance at this time is the night temperature which should be high enough to permit heavy oviposition. The variation in night temperature of a few degrees during this period probably accounts for a year of severe or light infestation of the codling moth.

It will be noted, from the preceding comparison of orchard temperatures, that the variation in night temperature between two orchards may be as great as that between two seasons. A variation of  $6^{\circ}$  to  $8^{\circ}$ , such as frequently occurs, may altogether prevent oviposition of first-brood eggs in one orchard, and yet permit heavy oviposition in another. The fact that temperature falls more rapidly before dark in one orchard than in another is almost as significant as the extreme differences in night temperature, for a favorable temperature at the time darkness begins, even though the zero point is passed later, may give enough time for oviposition.

### FORECASTING OF BROODS

Perhaps the consideration of greatest importance in seasonal history studies of the codling moth is the forecasting of the date of earliest hatching of larvae of the first and second broods.

It was found best to base the forecasts of the beginning of hatching of the first brood on the first oviposition by moths of the spring brood. The interval between first oviposition and first hatching was always very regular, and in making forecasts 8 days were allowed. Emergence of moths, which was depended on as the indicator for second-brood oviposition, was entirely unreliable for first-brood oviposition, as has been shown by the seasonal history data, since the interval between first emergence and first hatching varied from 16 days in 1920 to 34 days in 1921.

In forecasting the hatching of second-brood larvae, the time of emergence of moths was depended on entirely, as it was fully as reliable as oviposition and gave a little more time. In making this forecast, 8 days (2 for preoviposition and 6 for hatching) were added to the first date of emergence of first-brood moths in appreciable numbers. This was a relatively simple matter in comparison with the timing of the beginning of the first brood.

Since forecasting the beginning of hatching of the first brood depends on oviposition records, it is necessary that the work be done by an entomologist. It is sometimes suggested that fruit growers themselves should keep a supply of overwintering larvae and time their spray applications by the appearance of the first moths, but, as just stated, in the Ozarks this is an unreliable indicator, even for an entomologist. One whose chief business is fruit growing has not the time to take oviposition records, even if he should have the requisite equipment and experience. In most instances, rearing work on a small scale

would serve only to confuse the grower. In order to secure records for all extremes of the overwintering individuals, it is advisable to rear at least 1,500 moths. Care must also be taken to keep the temperature of the oviposition cages as near normal as possible.

In some fruit regions, the hatching of the first brood is expected arbitrarily to begin between three and four weeks after the falling of the petals, and the first cover spray is applied accordingly at that time. This may be quite satisfactory in regions where there is less seasonal variation, but is entirely impractical in the Ozarks. In 1921 the interval between petal fall on the common varieties and first hatching was 43 days. In 1919 the actual interval was only 19 days, although 36 days intervened between petal fall and hatching in appreciable numbers.

The experiments regarding the relation of light and temperature to oviposition and the four years' records of oviposition in the insectary would indicate that the date of earliest hatching of first-brood codling moth larvae may be forecasted from records of temperature for the hour after sunset. This, however, needs further confirmation before it can be definitely recommended. Temperature records, of course, will indicate only the time when oviposition may occur. Hatching must be forecasted from that. Temperature before two weeks after petal fall need not be considered, according to the experience of the writers, for prior to that time moth emergence is so slight that only scanty oviposition, if any, could be expected. After this period, temperatures for the hour following sunset when the thermometer registered above 62° would indicate the time of beginning of real oviposition. It is necessary, of course, that favorable weather conditions continue for several nights if heavy oviposition is to occur.

### SUMMARY

The investigations upon which this paper is based were conducted at Bentonville, Ark., during the seasons of 1918, 1919, 1920, and 1921.

During these four years, emergence of moths from the overwintering larvae began as early as April 13 and as late as April 30. The bulk of the emergence was always in May. Oviposition began from May 3 to 9, and hatching was consistently 8 days later. However, oviposition in 1919, the year for which the earliest record was secured, was checked by cold weather almost immediately after beginning, and continuous oviposition did not begin until May 25, the latest date for the four years. The bulk of oviposition usually occurred in a period of about three weeks in the latter part of May and the first few days of June. The bulk of hatching was from 5 to 7 days later.

During the two years for which summer-brood records were taken, emergence of first-brood moths began June 15 and 24;

oviposition began June 19 and 27; hatching began June 25 and July 3. During the remainder of the season the broods overlapped, and codling moth infestation increased until near the close of adult activity in September.

The average duration of the different stages varied throughout the season with the variations in temperature. The average time required for the development of each stage at different periods of the season of activity is best indicated by the shortest and longest average for any 10-day period. The range of these averages is as follows:

Egg stage, 4.56 days in midsummer to 10 days in early spring; larval feeding period, 16.14 days in midsummer to 31.42 days in late autumn; prepupal period, summer broods only, 3.50 days to 5.44 days; pupal stage, 8.75 days in midsummer to 36.44 days in early spring; total period in cocoon, summer broods only, 13.56 days to 20.59 days.

The pre oviposition period is usually 2 days, and heavy oviposition is normally passed by the end of the eighth day. The period of oviposition may be greatly lengthened by cold weather.

The codling moth is very prolific during midsummer. During one 10-day period the average oviposition exceeded 110 eggs for each female moth. On the other hand, during the cooler part of the year, particularly in the spring, many moths fail altogether to deposit eggs. It has been found that light and temperature are important factors in limiting oviposition. At least partial darkness is necessary for heavy oviposition, and oviposition begins at a temperature above 62° F. This confines oviposition almost entirely to nights when the temperature is above 62° for at least a short period. The period of highest night temperature would normally be immediately after sunset.

The factors which limit oviposition are of particular importance in their effect upon the reproduction by moths of the spring brood. If low night temperatures prevail during the month of May, so few eggs may be deposited that only a small first brood of larvae develops, and as a result a season of light infestation follows. On the other hand, if the night temperatures are favorable during the period of overwintering brood emergence, a season of severe codling moth infestation may be expected to follow.

In the same way, if there are local variations in temperature at night, they may be expected to affect the local severity of codling moth infestations. Thermograph records in two orchards of the same vicinity showed marked differences in temperature occurring the same nights. In one instance the difference in minimum temperature was 10° F. Short crops, natural enemies, and differences in the varieties of apples occurring in an orchard are also responsible for the great differences between orchards in natural severity of the codling moth problem.

It appears from the four years' records that the date of hatching of first-brood larvae, a date of great importance in timing of spraying operations, may be forecasted by the temperature records for the hour following sunset. In an ordinary season oviposition may be expected the first night when the temperature for this period is above 62°, provided this night is at least two weeks after the petals fall. However, this method of forecasting the first brood needs further confirmation before it should be recommended. For the present, the rearing of large numbers of overwintering larvae and securing oviposition records from the resulting moths must be depended upon for forecasts.

### REMEDIAL MEASURES

It is not the purpose of this paper to make any report of experimental spraying, and only a summary of methods recommended will be given.

Spraying with arsenate of lead at the rate of 1 pound (powdered) to 50 gallons of liquid is the main dependence in codling moth control. As a rule, a total of six or seven applications is necessary.

The first application, known as the calyx spray, is made after 90 per cent of the petals have fallen, and before the calyx cups close. The time of making this application has no relation to seasonal history. Its purpose is to drive poison into the calyx cavity, and it is of importance in the control of larvae of all generations which attempt to enter at the calyx end of the apple.

To control larvae of the first generation, two applications (first and second cover sprays) are usually recommended. The first cover spray should be finished about the time of the beginning of hatching of "worms" and the second should be finished just before the height of the hatching of the first brood. It is possible that the period of hatching may be so extended that three cover sprays are necessary.

For the summer generations of codling moth, a series of three or four applications, depending on the season, are recommended. The last of these applications (the third cover spray) should be finished just before the beginning of hatching of the second brood, and the other applications should follow at intervals of three weeks.

Control of the codling moth is usually combined with the control of fungous diseases of the apple and consequently, arsenate of lead is usually applied in combination with a fungicide, either lime sulphur solution or Bordeaux mixture. Applications can be made most effectively by the use of a power sprayer, maintaining about 225 pounds pressure. Spray rods should be equipped with angle nozzles. The most satisfactory size of the perfor-

ation in the disc of these nozzles is  $1/16$  inch for the calyx spray and  $1/24$  inch for subsequent applications.

To determine the exact time when spray applications should be made for the beginning of the first brood and the beginning of the second brood, large numbers of codling moths have been reared and temperature records have been taken at the insectaries of the State Experiment Station at Fayetteville and the U. S. Entomological Laboratory at Bentonville. This information has been made available to fruit growers through both of these agencies.











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